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Musselshell Basin

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

MISSOURI - MUSSELSHELL BASIN
JAWBONE NO. 1 DAMS AND RESERVOIR
JAWBONE NO. 2 DAM AND RESERVOIR
HARLOWTON, MONTANA
MT-70 (NO. 1)
MT-785 (NO. 1)
MT-71 (NO. 2)

PREPARED FOR:

HONORABLE TED SCHWINDEN
GOVERNOR, STATE OF MONTANA

CITY OF HARLOWTON
(OWNER/OPERATOR)

PREPARED BY:
HOSKINS-WESTERN-SONDEREGGER, INC.

APRIL, 1981

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers and with representation from the State of Montana Department of Natural Resources and Conservation and the City of Harlowton (Owner), Hoskins-Western-Sonderegger, Inc. (HWS) inspected the Jawbone Creek Project on 9 May 1979 under the authority of Public Law 92-367. The Jawbone Creek Dams are located in Wheatland County, Montana, at the northwest corner of the City of Harlowton. The purpose of the Jawbone Creek Dams is to provide flood control for the City of Harlowton.

This report was compiled from information obtained during an on-site inspection, a review of construction plans and the owner's records, and analysis of hydrologic and hydraulic data. Findings were compared to engineering criteria currently accepted by most private and public agencies engaged in dam design, construction, and operation.

PRINCIPAL FINDINGS AND EVALUATION

The upper reservoir, formed by Dam 1 and Dike 1, has a drainage area of 1.97 square miles, a maximum surface area of 188 acres, and maximum storage of 1,933 acre-feet. The lower reservoir, formed by Dam 2, has a drainage area of 2.19 square miles (including the 1.97-square-mile drainage area of the upper reservoir), a maximum surface area of 13.7 acres, and maximum storage of 113 acre-feet.

In accordance with the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), the 31-foot-high Jawbone Dam 1 (MT-70) and the 13-foot-high Dike 1 (MT-785) are classified as being of intermediate size, based on storage in their reservoir. The 36-foot-high Jawbone Dam 2 (MT-71) is classified as being of small size. These three structures all have high (Category 1) downstream hazard potential classifications due to the presence of U.S. Highway 12 and the City of Harlowton below the dams. Under normal conditions, no water is impounded in the two reservoirs. Slide gates in the conduits of both dams are locked in established partially-opened positions.

Inspection criteria (Ref. 1) recommend that a small-sized project with a high downstream hazard potential be capable of safely handling a flood in the range of one-half the probable maximum flood (PMF) to the PMF. In addition, the criteria recommend that an intermediate-sized project with a high downstream hazard potential be capable of safely handling a flood equal to the PMF. The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Considering the large number of inhabitable structures within the flood path and the potential for extensive property damage, we recommend that the entire project safely handle the full PMF.

An estimated PMF was developed for the drainage basins during the dam safety analysis. Reservoir routings of the estimated PMF indicate that the entire project will handle a flood having hydrograph ordinates equal

to 41% of the PMF hydrograph ordinates without overtopping any of the embankments. Larger floods will overtop the embankments.

The dams are constructed of materials that will erode and fail when overtopped by floodwaters. Such failure could endanger the lives of many people and cause extensive property damage in the City of Harlowton. No dam breach analysis or routing of a dam breach flood was made for the downstream area. The conclusions on probable damage are based on a brief field visit and engineering judgment. On the basis of the field inspection and the study of hydrologic and operational data, the Jawbone Creek Project does not conform to the recommended guidelines with respect to discharge and/or storage capacity to safely handle the PMF.

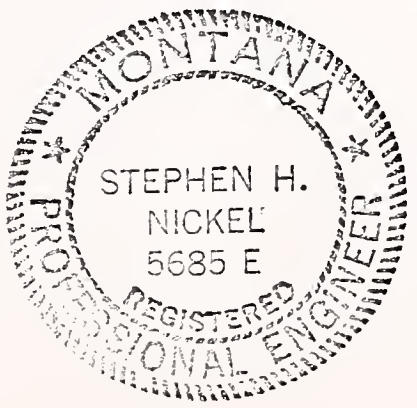
No seepage or evidence of seepage was found during the visual inspection of the embankments. At the time of inspection, no water was impounded by the dams. No piezometers are installed to measure water levels in the embankments. Dam 1 contains a blanket toe drain. The downstream faces of Dam 1 and Dike 1 show evidence of frost disturbance. Dam 1 has a small hole immediately downstream from the low-level inlet. This hole appears to have been caused by water seeping into the low-level conduit or along it. Dam 2 shows evidence of a longitudinal crack, approximately 120 feet long extending approximately over the maximum section of the dam, just below the upstream crest. All the embankments show considerable evidence of burrowing animals. Insufficient information is available to adequately evaluate stability of the embankments.

PRINCIPAL RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

A downstream warning plan, for use in the event of possible dam overtopping, must be developed and immediately placed in operation. Conduct more-detailed hydrologic and hydraulic routing studies for the project to better determine the downstream hazard and required spillway capacities. Modify the project as studies indicate.

Prior to performing engineering studies and remedial construction, all work should be coordinated with the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.



Stephen H. Nickel
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal Identification No.	MT-70 (Dam 1), MT-71 (Dam 2), MT-785 (Dike 1)
Owner/Operator	City of Harlowton, Montana
Purpose	Flood Control
Location	Sections 21 and 22, T8N, R15E Wheatland County, Montana
Watershed	Jawbone Creek, Tributary to Musselshell River
Downstream Hazard Potential	Category I (High)
USGS Quadrangle	None
AMS Map	Roundup, Montana

2. RESERVOIR

	MT-70, MT-785	MT-71
Surface Area at Normal Pool	0 acres	0 acres
Storage at Normal Pool	0 acre-ft	0 acre-ft
Total Storage (Min. Dam Crest)	1933 acre-ft	113 acre-ft
Surcharge Storage	1933 acre-ft	113 acre-ft
Drainage Area	1.97 sq mi	2.19 sq mi

3. EMERGENCY SPILLWAYS

	MT-70, MT-785	MT-71
Type	Uncontrolled earth Channel	Uncontrolled earth Channel
Crest Elevation	4261.4 feet (NGVD)	4232.9 feet (NGVD)
Width	20 feet	Varies
Spillway Capacity (Min. Dam Crest)	140 cfs	400 cfs

4. PRINICPAL SPILLWAY OUTLET WORKS

	MT-70	MT-71
Type	Controlled reinforced concrete conduit with asbestos cement low-level outlet pipe and closed-top, reinforced concrete ported riser	Controlled reinforced concrete conduit with asbestos cement low-level outlet pipe and closed-top, reinforced concrete ported riser
Controls	Slide gate with manual control from top of riser	Slide gate with manual control from top of riser
Size	24" diameter conduit 12" diameter low-level outlet pipe 2'-0"x10" port	24" diameter conduit 12" diameter low-level outlet pipe 2'-0"x10" port

Low-Level Inlet Crest	4237.0 feet (NGVD)	4211.0 feet (NGVD)
Riser Invert	4235.0 feet (NGVD)	4208.0 feet (NGVD)
Conduit Outlet Invert	4233.0 feet (NGVD)	4203.0 feet (NGVD)
℄ Port	4248.0 feet (NGVD)	4220.0 feet (NGVD)
Normal Tailwater	4233.3 feet (NGVD) (Estimated)	4200.3 feet (NGVD) (Estimated)
Discharge Capacity (Min. Dam Crest)	51 cfs	53 cfs

5. DAM

	MT-70 (Dam 1)	MT-71 (Dam 2)	MT-785 (Dike 1)
Type	Earth	Earth	Earth
Maximum Height (Hydraulic)	31 feet	36 feet	13 feet
Size Classification	Intermediate	Small	Intermediate
Crest Length	650 feet	430 feet	780 feet
Crest Elevation (Min.)	4263.5 feet (NGVD)	4235.8 feet (NGVD)	4264.9 feet (NGVD)
Crest Width	14 feet	14 feet	11 feet
Upstream Slope	1V on 2.88 (H) Above Berm 1V on 4(H) Below Berm	1(V) on 2.67 (H) Above Berm 1(V) on 4(H) Below Berm	1(V) on 3.04(H)
Downstream Slope	1(V) on 2.14(H)	1(V) on 2.36(H)	1(V) on 1.98(H)

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Jawbone Creek Dams, owned and operated by the City of Harlowton, Montana.

The National Dam Inspection Act, Public Law 92-367 date 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Office of the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1) in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists, highly experienced in dam safety, from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines outline a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam;
(2) based upon an evaluation of the available data and a visual inspection;
(3) performed to determine if any emergency measures and/or additional studies, investigations and analyses are necessary or warranted; and
(4) not intended to include extensive explorations or analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, materials testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise.

The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and neither action nor failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on a 9 May 1979 visual inspection of the project, a brief engineering analysis, and an interview with the owners. Construction plans obtained from the Soil Conservation Service were also used in the analysis. Inspection procedures and criteria were those established by the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1).

Personnel present during the inspection included:

Louis Boitano, Civil Engineer, Corps of Engineers;
Lawrence Tegg, State of Montana, Department of Natural Resources and Conservation (DNRC);
Al Crawford, City of Harlowton; and
Charlie Gephart, Soil Conservation Service (SCS).

Hoskins-Western-Sonderegger, Inc. (HWS) personnel who participated in the field inspection and contributed to this report are:

Stephen Nickel, Geotechnical Engineer, Team Leader, and
Richard Walker, Hydrologist/Hydraulic Engineer.

This report has been reviewed by representatives of the DNRC, the SCS, and the owner. Written comments from the DNRC and the SCS are included in the Appendix of this report. The owner chose not to comment.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

The Jawbone Creek Dams are located in Sections 21 and 22, T8N, R15E, Wheatland County, Montana, at the northwest edge of the City of Harlowton. The dams are located on Jawbone Creek, a tributary of the Musselshell River, are owned and operated by the City of Harlowton, and are intended to provide flood control for Harlowton.

Dam 1 (MT-70), which is approximately 31 feet high, Dike 1 (MT-785), which is approximately 13 feet high, and another small 3-foot-high dike form the upstream reservoir. Inspection guidelines do not require evaluation of the small dike. This reservoir has a drainage area of 1.97 square miles, a maximum surface area of 188 acres at the minimum embankment crest elevation of 4263.5 feet, and a maximum storage of 1,933 acre-feet at the minimum embankment crest. The principal spillway, located in Dam 1, consists of a controlled, low-level outlet and a covered-top, ported riser. The emergency spillway, located at the west end of the reservoir, is an uncontrolled, earth channel, which discharges into another drainage basin. The control gate for the principal spillway is kept partially open to keep the reservoir drained and to limit discharges to the downstream areas. Dam 2 (MT-71), which is approximately 36 feet high, forms the downstream reservoir. This reservoir has a drainage area of 2.19 square miles, (including the 1.97-square-mile drainage area of the upper reservoir), a maximum surface area of 13.7 acres at the minimum dam crest elevation of 4235.8 feet, and a maximum storage of 113 acre-feet at the minimum dam crest. The principal spillway is of the same configuration as that of Dam 1. The emergency spillway, located in the left abutment of the dam, is an uncontrolled, earth channel which discharges into a natural gully below the left abutment. The control gate for the principal spillway for Dam 2 is kept partially open to keep the reservoir drained and to limit discharges to the downstream areas.

According to criteria in the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), Jawbone Dam 1 and Dike 1 are classified as intermediate size, and Jawbone Dam 2 is classified as small size. Based on visual reconnaissance and engineering judgment, part of the City of Harlowton, U.S. Highway 12, and the Milwaukee Railroad could be affected by a sudden breach of the dams. Dam 1, Dike 1, and Dam 2 are all classified, therefore, as having high downstream hazard potential.

1.2.2 Regional Geology

The drainage area of the Musselshell River is a region of basin and range complicated by thrust faulting. Geographically, the Big Snowy Mountains and the Little Belt Mountains are on the north, the Crazy Mountains are on the south, the Castle Mountains are in the middle, and the Big Belt Mountains are on the west, forming a semi-circle of mountains around a group of basins extending generally eastward onto the great plains. Before the late Cretaceous period, this was an area of quiet basinal sedimentation. Pre-Cambrian, Paleozoic, and Mesozoic sedimentation

produced sandstones and shales. These Pre-Cambrian and Lower and Middle Paleozoic sedimentary and metamorphic rocks are exposed in the mountains and are only exposed due to the mountain-building that occurred here.

During late Cretaceous times and Teritiary times, three possible phases of mountain building seem to have occurred: (1) initial Cretaceous uplift of the Central Montana arch; (2) late Cretaceous thrust faulting (as evident west of the White Sulphur Springs area), which produced attendant normal and high-angle reverse faulting, with fracture faulting also common; and (3) Tertiary igneous activity, which involved the formation of the Castle and Crazy Mountains. With the intrusion of these igneous bodies and the thrust faulting, the older Pre-Cambrian and Paleozoic rocks were uplifted and exposed, as in the case of the Big Belt Mountains. The attendant foothills of the ranges are of later Paleozoic and Lower Mesozoic sediments.

During this mountain-building phase, the basinal sediments were formed into a dome containing smaller anticlines and synclines, the most prominent of which are the Little Belt Mountains and the Snowy Mountains. Subsequent to the mountain building came erosion. Erosional debris from the mountains, swept down by rivers and streams, covered the earlier Cretaceous sandstones and shales and formed the Eocene Fort Union formation, consisting of sandstone, shale, and bituminous coal.

Subsequent erosion of this domed basin has produced the present topography which shows a rim of Fort Union deposits with succeedingly older Cretaceous deposts toward the center of the present smaller basins. These Cretaceous deposts are predominantly the sandstones and shales of the Livingston Formation. The oldest formation exposed in the basins is the Colorado Shale. Later Tertiary gravels and sand form the terraces and benches of the Musselshell River with Pleistocene alluvium along the recent bed of the river.

1.2.3 Seismicity

The Jawbone Creek Dams lie in Seismic Zone 2, as indicated by the Seismic Zone Map (Ref. 1). The seismic probability of Zone 2 is one of a potential for moderate damage and is based on the known distribution of damaging earthquakes in the region.

No major faults have been mapped in the immediate vicinity of the project, although traces of minor faults can be inferred from aerial photographs and topographic maps. No active faults were found or inferred at the sites of the embankments. The closest faults identified on the Geologic Map of Montana lie 9 miles northwest of the project and 25 miles southeast.

Epicenters of local earthquakes significant enough to be reported in References 2 and 3 occur approximately along a line from 20 miles northwest of Helena to 25 miles north of Bozeman. The 3 largest reported earthquakes along this line have had intensities of VIII (Modified Mercalli). One of these earthquakes had its epicenter at a point 25 miles north of Bozeman

(27 June 1925), while the other two occurred at Helena (18 October and 31 October 1935). Of these 2 epicentral areas, the former is 65 miles and the latter 120 miles from the reservoir. No reported earthquakes have occurred at distances of less than 65 miles from the project.

1.2.4 Site Geology

The project site lies near the eastern edge of a large syncline in an outcrop area of the Judith River formation. The syncline is perhaps 15 miles wide and has an axis running roughly northeast-southwest. The Judith River formation is comprised of sandstone, siltstone, and sandy shale.

Borings performed at the site of Dam 1 during investigations preceding design show shales and sandstones overlain by 1 to 4 feet of alluvial or residual soils. No borings were performed at the site of Dike 1. The emergency spillway for the reservoir retained by Dam 1 and Dike 1 is shown on the construction plans to be cut into silt, weathered shale, and soft sandstone and to have hard shale or sandstone within a few feet below the flowline.

The borings for Dam 2 show up to 10 feet of alluvial or residual soils. The soil thins to about 1 foot thick in the abutments. The soil overlies weathered shale and weathered sandstone. No borings were made along the emergency spillway of Dam 2.

1.2.5 Design and Construction History

The Jawbone Creek structures were designed in 1965 by the Soil Conservation Service. Construction plans, a geology report, geotechnical test results, and evidence of a manual slope stability computation for the case of drawdown on Dam 1 were obtained from the SCS. A formal geotechnical report was not available for review. Construction was completed in 1966 or 1967. The structures were part of the Jawbone Creek Watershed Protection and Flood Prevention Project. The project was federally funded under the authority of PL-566.

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Emergency Spillways

Upper Reservoir

The emergency spillway for the upper reservoir (the reservoir retained by Dam 1 and Dike 1) is located at the extreme west end of the reservoir, approximately 3,800 feet west of Dam 1 and 3,500 feet west of Dike 1. This spillway discharges into the Lehi Creek drainage basin. The spillway is an uncontrolled, grass-lined, earth channel consisting of a 250-foot long approach channel, a 400-foot-long, flat, control section, and a 300-foot-long exit channel. The channel is of uniform cross section with a 20-foot-wide bottom and 1(V) on 2(H) side slopes. The maximum channel depth is approximately 5 feet. A corrugated metal pipe irrigation flume with two wooden supports crosses the channel at approximately the middle of the flat crest section. The emergency spillway configuration is shown on Plate 6 and on Plate 17 (sheet 6 of 15 of the SCS plans). The emergency spillway channel can also be seen in Photographs 11 and 12.

The emergency spillway channel is in good condition with no evidence of erosion damage. According to the owner/operator, the spillway has never operated. Some slumping of the banks has occurred as can be seen in Photograph 12. Erosion of the exit channel is likely to occur during high flows, but this will pose no threat to the integrity of the dam or dike.

The bottom of the irrigation flume crossing the emergency spillway channel is approximately 2 feet above the minimum dam crest elevation and, therefore, would not be damaged by spillway flows. The two wooden supports for the flume would be subjected to flows approximately 2 feet deep moving at approximately 3 feet per second at maximum spillway flow. Repeated instances of this flow could cause erosion around these supports.

The discharge rating for the emergency spillway was computed by assuming critical depth at the downstream end of the flat crest section and computing water surface profiles upstream into the reservoir using a Manning's "n" of 0.030. The capacity of the emergency spillway varies from 0 at the spillway crest elevation of 4261.4 feet to 140 cubic feet per second (cfs) at the minimum dam crest elevation of 4263.5 feet. The complete discharge rating curve is shown on Plate 10.

Lower Reservoir

The emergency spillway for Dam 2, downstream from Dam 1 and Dike 1, is located in the left abutment of Dam 2. This spillway is also an uncontrolled, grass-lined, earth channel. The approach channel, located along

the left upstream abutment trough of the dam, is approximately 250 feet long. This approach channel leads to a 50-foot-long, flat, control section. Flows over the spillway crest discharge into a natural gully which leads downstream from the left abutment of the dam. The bottom width of the spillway channel varies from approximately 14 feet at the control section to 35 feet in the approach channel. The dam forms the right (looking downstream) side of the approach channel and has a slope of approximately 1(V) on 3(H). The left wall of the approach channel has a slope of 1(V) on 2(H). A cross section of the channel at the crest is shown on Plate 7. The emergency spillway crest elevation was determined by field measurements to be 4232.9 feet (see Plate 7), rather than 4231.0 feet, as shown on the plans (see Plate 19). The approach channel, control section, and exit channel, respectively, can be seen in Photographs 19, 20 and 21.

The emergency spillway channel is in good condition with no evidence of erosion damage. According to the owner/operator the spillway has never operated. The approach channel and control section do not appear to be susceptible to erosion damage. High flows, however, could cause erosion in the gully which acts as the exit channel. Erosion of the gully could cause damage to the embankment.

The discharge rating for the emergency spillway was computed assuming critical depth at the crest and computing water surface profiles upstream into reservoir using a Manning's "n" of 0.030. The capacity of the spillway varies from 0 at the spillway crest elevation of 4232.9 feet to 400 cfs at the minimum dam crest elevation of 4235.8 feet. The complete discharge rating curve is shown on Plate 11.

2.1.2 Principal Spillway Outlets

Upper Reservoir

The principal spillway outlet for the upper reservoir is located at Sta. 4+00 of Dam 1. The principal spillway consists of an ungated, low-level inlet structure; a 12-inch diameter, asbestos-cement, draw-down conduit; a 3-foot by 3-foot reinforced concrete, covered-top riser with a 24-inch by 10-inch ungated port; a 24-inch-diameter, controlled, reinforced concrete outlet conduit; and a rock riprap outlet plunge pool. The 12-inch-diameter draw-down conduit, which runs from the low-level inlet structure to the riser, is approximately 44 feet long. The 24-inch-diameter outlet conduit, which runs from the riser to the outlet, is approximately 144 feet long. The controls for the outlet conduit consist of a 24-inch-by-24-inch slide gate, which is operated from the top of the riser by a 24-inch-diameter handwheel lift. According to the Operation and Maintenance Agreement (Appendix A), the slide gate is to be left in a pre-set, partially open position at all times, except for maintenance operations. The lift mechanism is secured to prevent tampering with the position of the slide gate. The principal spillway configuration is shown on Plate 16 (Sheet 5 of 15 of the SCS plans).

All visible principal spillway appurtenances were found to be in good condition. There was no evidence of any cracking, spalling, erosion, or settlement in the low-level inlet structure, riser, or conduits, although it was not possible to inspect the entire length of the conduit. The trash racks were free of debris. Some rusting of the metal bars was evident. Minor erosion and undercutting around the outlet conduit was observed in the plunge pool, as shown on Photograph 6; however, this does not pose any threat to the integrity of the embankment.

The discharge capacity of the principal spillway, with the gate in the pre-set, partially open position, was determined from the rating curves provided on the SCS construction plans. The capacity, for this case, varies from 0 cfs at the low-level inlet crest elevation of 4237.0 feet to 14 cfs at the minimum dam crest elevation of 4263.5 feet. The discharge capacity with the gate fully open was calculated based on the full pipe flow equation for the 12-inch-diameter drain conduit and the orifice flow equation for the 24-inch by 10-inch port. Discharge capacity with the gate fully open varies from 0 cfs at elevation 4237.0 feet to 51 cfs at elevation 4263.5 feet.

Lower Reservoir

The principal spillway outlet for Dam 2 is located at Sta. 4+13 of the dam. The principal spillway is the same type as that of the upstream dam with the configuration shown on Plate 20 (Sheet 9 of 15 of the SCS plans). The 12-inch-diameter draw-down conduit is approximately 30 feet long, and the 24-inch-diameter outlet conduit is approximately 144 feet long. The Operation and Maintenance Agreement (Appendix A) also specifies that the 24-inch-by-24-inch slide gate be kept in a pre-set, partially open position year-round, except for maintenance operations. The lift mechanism is also secured, to prevent tampering with the slide gate position. The low-level inlet structure, riser port, and outlet plunge pool can be seen in Photographs 16, 17, and 18, respectively.

All visible principal spillway appurtenances were found to be in good condition. There was no evidence of any cracking, spalling, erosion, or settlement in the low-level inlet structure, riser, or conduits, except that some settlement was observed in the outlet conduit. Some exposed reinforcement was also observed at the end of the outlet conduit. It was not possible to inspect the entire length of the conduits. The trash racks were free of debris. Some rusting of the metal bars was evident. Some erosion and undercutting around the outlet conduit was observed in the plunge pool, as can be seen in Photograph 18; however, this does not pose any threat to the integrity of the embankment.

Discharge capacities for the principal spillway were determined in the same manner as for the upstream dam. With the gate in the pre-set, partially open position, the capacity varies from 0 cfs at the low-level inlet crest elevation of 4211.0 feet to 13 cfs at the minimum dam crest elevation of 4235.8 feet. With the gate fully open, the capacity varies from 0 cfs at elevation 4211.0 feet to 53 cfs at elevation 4235.8 feet.

2.1.3 Freeboard

Since the outlet control gates for both the upper and lower reservoirs are normally left in a partially open position, both reservoirs are normally drained. At the time of inspection the water surface elevation of both reservoirs was approximately 1 foot above the low-level inlet crest elevation. According to the owner/operator, the highest observed reservoir level for Dam 1 was 3 to 4 feet below the principal spillway port, which is approximately 19 feet below the minimum dam crest elevation. The highest observed reservoir level for Dam 2 was the principal spillway port elevation, which is approximately 16 feet below the minimum dam crest elevation, and was caused by plugging of the low-level inlet by vandals.

The vertical distance between the emergency spillway crest elevation and the minimum dam crest elevation is 2.1 feet for Dam 1, 3.5 feet for Dike 1, and 2.5 feet for Dam 2. With the reservoir at the emergency spillway crest, the effective fetch distance for wind-generated waves is 0.5 miles for both Dam 1 and Dike 1 and 0.13 miles for Dam 2. The total of wave run-up and wind set-up is 2.9 feet for Dam 1, 3.5 feet for Dike 1, and 1.6 feet for Dam 2. Dam 1 and Dike 1, therefore, could be overtopped by wind-generated waves with the reservoir at the emergency spillway crest; however, this is not considered a significant problem for this project. For Dam 2 the vertical distance between the minimum dam crest elevation and the reservoir level would be 0.9 feet under these conditions (Ref. 4).

Reservoir routings indicate that Dam 1, Dike 1, and Dam 2 would all be overtopped by the Probable Maximum Flood (PMF); therefore, no freeboard is available during the PMF.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 Climatology and Physiography

The climate of the area around the Jawbone Dams and Reservoirs is continental and characterized by a large daily and seasonal temperature range. Extreme variability of wintertime temperature results from the frequent occurrence of chinook winds which follow a Pacific maritime airmass invasion. The summers are characterized by warm days with low humidity and cool nights. Winters are usually cold but highly variable in severity from year to year and within a given year.

Harlowton is the nearest climatological station representative of the damsites. Precipitation and climatological data are available for approximately 90 and 70 years, respectively. Average annual precipitation at Harlowton is approximately 14 inches, with over 60 percent of the precipitation falling from March through August. Average annual snowfall is approximately 37 inches. Temperature extremes range from -50°F to 100°F. The average expected date of the first freeze is September 7, and the average expected date of the last freeze is June 4 (Ref. 5 and 6).

The drainage area of Jawbone Dam 1, which lies to the northwest of the dam, is approximately 1.97 square miles. The Twodot Canal crosses the

watershed from west to east approximately 1 mile north of Dam 1. Basin elevations range from 4235 feet at the dam to approximately 4500 feet at the drainage divide. The watershed consists of rolling hills with short grass cover.

The drainage area of Jawbone Dam 2, which lies to the southeast of Dam 1, is approximately 2.19 square miles (including the 1.97-square-mile drainage area of the upper reservoir). Basin elevations between Dam 1 and Dam 2 range from 4210 feet at the dam to approximately 4275 feet at the basin divide. The small watershed between Dam 1 and Dam 2 consists mainly of the grass-covered slopes on either side of the lower reservoir.

2.2.2 Reservoir Storage and Spillway Discharge

Upper Reservoir

As has been previously stated, the outlet control gates for the Jawbone dams are normally left partially open, to keep the reservoirs drained. Jawbone Dam 1 has approximately 1,933 acre-feet of storage between the low-level inlet crest elevation of 4237.0 feet and the minimum dam crest elevation of 4263.5 feet. Reservoir surface area at the minimum dam crest elevation is approximately 188 acres. Discharge through the emergency spillway with the reservoir at the dam crest is approximately 140 cfs. Discharge through the principal spillway outlet is approximately 14 cfs, with the control gate in the pre-set, partially open position, and approximately 51 cfs, with the control gate fully open.

Lower Reservoir

Jawbone Dam 2 has approximately 113 acre-feet of storage between the low-level inlet crest elevation of 4211.0 feet and the minimum dam crest elevation of 4235.8 feet. Reservoir surface area at the minimum dam crest elevation is approximately 14 acres. Discharge through the emergency spillway with the reservoir at the dam crest is approximately 400 cfs. Discharge through the principal spillway outlet is approximately 13 cfs, with the control gate in the pre-set, partially open position, and approximately 53 cfs, with the control gate fully open.

Complete stage-area and stage-storage curves for the reservoirs are shown on Plates 8 and 9. Complete discharge rating curves for the emergency spillways are shown on Plates 10 and 11. Discharge rating curves for the principal spillway outlets are contained in the SCS plans.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meterologic and hydrologic conditions that are reasonably possible in the region. A probable maximum precipitation (PMP) storm of 72-hour duration was applied to Jawbone dams' drainage basins. The 6-hour, 12-hour, 24-hour, 48-hour, and 72-hour PMP depths were estimated from Ref. 7 to be 13.8 inches, 17.3 inches, 20.3 inches,

23.1 inches, and 25.2 inches, respectively. All 6-hour increments from 0 to 72 hours were arranged in accordance with criteria in Ref. 8.

The PMF was assumed to result from a PMP storm occurring in late spring over hard and frozen ground. A constant soil loss rate of zero was, therefore, applied throughout the 72-hour PMF storm, in accordance with Corps of Engineers recommendations. The PMF is, therefore, not affected by soil losses, and runoff is equal to rainfall for all storm increments.

Direct precipitation onto the surface of both reservoirs was added in with no losses. Inflow from a breach of the Twodot Canal was also directly added in. This canal was assumed to have intercepted floodwaters from outside the basin, breached, and contributed at its capacity of 122 cfs for the entire duration of the storm.

2.2.4 Flood Routing

A flood routing of the PMF was made to determine the percentage of the PMF volume that could be handled by reservoir storage and spillway discharge before overtopping of the dams. This analysis was based on the present operating procedures of the project. Since the Jawbone Creek Reservoirs are normally lower than the emergency spillway crest elevations, an antecedent storm of 100-year return period and 4-day duration was evaluated to estimate the reservoir levels at the beginning of the PMF. The reservoirs were assumed to be drained at the beginning of this antecedent storm. At the end of the 100-year, 4-day storm, or the beginning of the 72-hour PMF, it was determined that the upper reservoir would contain approximately 500 acre-feet of storage, with the slide gate in the pre-set, partially open position and approximately 160 acre-feet with the slide gate fully open. For the lower reservoir, it was determined that the 100-year, 4-day storm would fill the reservoir to the emergency spillway crest, and, therefore, the 72-hour PMF was assumed to begin with the reservoir filled to the emergency spillway crest.

The total volume of the 72-hour PMF for Dam 1 is approximately 3,370 acre-feet, with a peak flow rate of approximately 7,510 cfs. For Dam 2 the total volume of the 72-hour PMF, excluding inflow from Dam 1, is approximately 300 acre-feet, with a peak flow rate of approximately 1,470 cfs. Flood routings indicate that both dams will overtop during the PMF.

Routings were also made of lesser hypothetical floods than the PMF to determine the magnitude of floods the dams can contain. The hypothetical hydrographs were obtained by applying percentages to the PMF ordinates. Floods having hydrograph ordinates corresponding to 41% (gates in pre-set, partially open position) and 51% (gates fully open) of the PMF ordinates are just controlled by the project. Larger floods would overtop the dams.

Assuming the Twodot Canal to breach and contribute to the PMF within the Jawbone Creek basin is the worst condition. The canal could breach outside the basin, which would result in better flood routing capability than that indicated here.

The PMF hydrographs were developed using the SCS dimensionless unit hydrograph. Reservoir routings of the inflow hydrographs were made using the modified Puls method. The HEC-1 (Dam Safety Version) computer program (Ref. 9) was used for the hydrograph computations and reservoir routings.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Embankments

Dam 1

The 31-foot-high Dam 1 embankment is 650 feet long and has a crest width of 14 feet. The upstream slope is 1(V) on 2.88(H) for approximately the upper 18 feet. At that point there is an 8-foot wide berm. The slope below the berm is 1(V) on 4(H). The downstream slope is roughly 1(V) on 2.14(H). The construction plans (see Plate 14) indicate that the embankment material was obtained from a borrow area immediately north of the damsite. The material exposed on the surface of the embankment appears to be a clayey silt with some sand and gravel, especially on the upstream face. This embankment material is considered to be readily erodible and can be expected to fail rapidly on overtopping. There are rodent holes on all surfaces of the embankment. Water flowing in rodent holes can lead to rapid embankment failure during times of high reservoir levels.

The embankment is covered with grass. There is no riprap. Previous occasions when the reservoir has contained water have produced no noticeable erosion.

Dike 1

The 13-foot-high dike embankment, south of Dam 1, is 780 feet long and has a crest width of 11 feet. The upstream slope is 1(V) on 3.04(H). The downstream slope is 1(V) on 1.98(H). The borrow area indicated on the plans for this embankment is the same borrow area as for Dam 1. The material exposed on the surface of the embankment and the vegetation appear to be the same as for Dam 1. There are rodent holes on all surfaces of the embankment.

Dam 2

This embankment is 36 feet high, with a length of 430 feet and a crest width of 14 feet. The upstream slope is 1(V) on 2.67(H) for the upper 17 feet. There is an 8-foot-wide berm roughly 17 feet below the crest of the dam. The slope below the berm is 1(V) on 4(H). The downstream slope measures 1(V) on 2.36(H). The borrow area indicated on the construction plans for Dam 2 was immediately upstream from the right abutment of the embankment. The material exposed on the surfaces of the dam appears to be a sandy to clayey silt. This material is considered to be readily erodible. Rapid failure can be expected on overtopping. There are rodent holes on all surfaces of the embankment. Water flowing in rodent holes can lead to rapid embankment failure during times of high reservoir levels.

The embankment is covered with grass on the upstream face and the crest. The downstream slope is vegetated with grass, sage, wild roses, and prickly pear. There is no riprap. Previous occasions when the reservoir has contained water have produced no noticeable erosion.

2.3.2 Foundation Conditions, Seepage, and Drainage

Dam 1

This dam is founded on alternating shales and sandstones which are relatively flat-lying. The construction plans show a shallow cutoff trench running the entire length of the dam at the dam centerline. The cutoff is shown to be up to 4 feet deep with a 10-foot bottom width and 1 on 1 side slopes (see Plate 15). In addition, the construction plans show a blanket drain, extending horizontally from the downstream toe to within 35 feet of the dam centerline. The drain extends from approximately 50 feet right of the conduit to approximately 110 feet left of the conduit. The thickness of the drain is shown to vary from 2 feet to approximately 4 feet. It is continuous over the top of the conduit. At the time of the inspection, the reservoir was drained, and there was neither seepage nor evidence of previous seepage at any location, including the vicinity of the drain. Since the reservoir is normally dry, no seepage would be expected. There is no instrumentation, such as piezometers, installed in Dam 1.

Dike 1

The foundation for Dike 1 is similar to that of Dam 1. However, the construction plans show Dike 1 to have neither a cutoff nor a blanket toe drain. Since the height of Dike 1 is only 13 feet, such measures are probably not necessary. Dike 1 also has no instrumentation. No evidence of seepage was found.

Dam 2

Dam 2, as shown on Plate 20, is founded on alternating shales and sandstones. A cutoff trench is incorporated in the design. It ranges up to 4 feet deep, with a 10-foot-wide bottom and 1 on 1 side slopes. The construction plans show no drains in this embankment. As with the other embankments, Dam 2 has not been instrumented. No evidence of seepage was found.

2.3.3 Stability

Dam 1

There is a hole, about 1.5 feet deep and 1.5 feet in diameter, centered approximately 3 feet downstream from the low-level inlet and directly above the conduit. This hole may indicate leakage into a joint or a break in the conduit, or it may be evidence of seepage along the conduit. The cause of the hole will have to be determined and remedied. The downstream slope has many small, surface cracks and shows some evidence of minor

movement of the surface materials. The cracks and the movement both appear to be caused by frost action in the silty embankment material. This appears to be more an appearance problem than a stability problem. There is a sag in the crest of the embankment, centered approximately 40 feet left of the outlet conduit centerline, which appears to have been caused by embankment consolidation. The sag has not caused any visible cracks in the embankment. The method of reservoir operation apparently precludes the development of a phreatic surface; however, a detailed stability analysis is not available. It is our judgment that sufficient information is not presently available for evaluation of stability.

Dike 1

There is slight surface disturbance on the downstream slope similar to that on Dam 1, probably caused by frost action. There is no other evidence of instability. As with Dam 1, it is our opinion that sufficient information is not presently available to adequately evaluate stability.

Dam 2

There is no sign of instability on the downstream slope, although there is some animal damage. A sag is visible in the crest of the embankment, centered about 20 feet right of the outlet conduit centerline. This is the location of both the maximum embankment section and the probable maximum thickness of any compressible foundation soil. In roughly the same location as the sag, there is a longitudinal crack, approximately 120 feet long. The crack begins 55 feet left of the right abutment and runs toward the center of the dam, in a location about 1 to 4 feet below the upstream shoulder of the embankment. A small scarp is visible at some points, and rodent holes are concentrated along the crack and scarp. The cause of the crack is not known. If remedial measures are not taken, a slope failure could develop in the upstream face. A detailed stability analysis is not available for review. Although sufficient information is not presently available for evaluation of stability, in our judgment, the observed crack may pose a threat to embankment stability during sustained high reservoir levels or under sudden drawdown conditions.

2.4 PROJECT OPERATION AND MAINTENANCE

2.4.1 General

Operation and maintenance of the Jawbone Creek Dams and Reservoirs is the responsibility of the City of Harlowton with technical assistance provided by the Soil Conservation Service. The plan for operation and maintenance of the structures is detailed in the 1966 "Operation and Maintenance Agreement" between the City and the SCS, a copy of which is included in this report (see Appendix A). This agreement specified that the structures will be inspected at least annually. Records provided by the Upper Musselshell Conservation District indicate that the structures have been inspected in 1968, 1970, 1971, 1975 and 1977.

2.4.2 Embankments

Maintenance of the embankments is performed by the City of Harlowton, as required. Although there are some minor maintenance items that currently need to be performed, the project appears to be generally well-maintained.

2.4.3 Reservoirs

The 1966 "Operation and Maintenance Agreement" specified that the outlet control gates shall be "closed to the preset opening at all times" in order to prevent flooding downstream in Harlowton. Discussions with Mr. John Crowley, City Engineer, and with SCS personnel indicated that this policy is adhered to. Measures have also been taken to prevent tampering with the gate lift mechanisms. The Jawbone Creek Reservoirs, therefore, are normally drained and left free to store watershed runoff.

2.4.4 Warning Plan

There is no formal plan of action to warn downstream inhabitants or interests in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the Jawbone Creek Dams, supplemented by analysis of the project in terms of the recommended guidelines' performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification and Safety Evaluation

According to the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), Jawbone Dam 1 (MT-70) and Dike 1 (MT-785) are classified as intermediate size. Jawbone Dam 2 (MT-71) is classified as small size. On the basis of visual inspection and engineering judgment, Dam 1, Dike 1, and Dam 2 are all classified as having high downstream hazard potential. The recommended spillway design flood (SDF) for this project is, therefore, 100% of the PMF. Based on reconnaissance level investigations, this project, as presently operated, is incapable of handling the recommended SDF without overtopping and causing the dams to fail, which, in our judgment, could seriously jeopardize life and property downstream. Therefore, the project is not in conformance with inspection guidelines.

3.1.2 Embankments

Dam 1

Since this dam is operated without a normal pool, no seepage was anticipated, and none was found. A hole was found in the embankment (see Photo 4), immediately downstream from the low-level inlet. The hole did not appear to have been made by an animal. It appeared to have been made by water, either seeping into the conduit or seeping along the outside of the conduit during periods of elevated reservoir water levels. There are rodent holes on all surfaces of the embankment.

The surface material on the downstream slope appeared to have been disturbed, perhaps by frost action. The surface material had a fluffy texture and showed several small, surface cracks. Some downslope movement of the near-surface material appeared to have occurred.

The embankment crest is not level and is lowest near the highest embankment section. This is also the vicinity of the conduit.

There is no instrumentation, such as piezometers, installed in the dam.

Sufficient information is not presently available to determine whether Dam 1 conforms to the recommended guidelines with respect to stability (Ref. 1).

Dike 1

The base of the dike is above the apparent high-water level in the reservoir. Therefore, no seepage or evidence of seepage was anticipated, and none was found. The surface of the downstream slope appears to have suffered minor frost disturbance. There are rodent holes on all surfaces of the embankment.

There is no instrumentation, such as piezometers, installed in the dam.

Sufficient information is not presently available to determine whether Dike 1 conforms to the recommended guidelines with respect to stability (Ref. 1).

Dam 2

Dam 2 displayed no evidence of seepage. The downstream slope showed some animal damage, primarily what appeared to be cattle trails. All surfaces of the embankment had numerous rodent burrows.

There is a depression on the crest of the embankment, near the right abutment. This is in the location of the maximum embankment section, the maximum thickness of compressible foundation soil, and the conduit. Just below the upstream shoulder of the embankment, in this same area, there is a crack, approximately 120 feet long, which runs roughly parallel to the axis of the dam. Repair is required to avoid problems in the future.

There is no instrumentation, such as piezometers, installed in the dam.

Sufficient information is not presently available to determine whether Dam 2 conforms to the recommended guidelines with respect to stability (Ref. 1).

3.1.3 Emergency Spillways

Both emergency spillway channels were in good condition with no evidence of erosion damage. According to the owner/operator, neither spillway has ever operated.

3.1.4 Principal Spillway Outlets

The visible portions of the principal spillway outlets of both dams were in good condition. Although the entire lengths of the conduits were not inspected, observation from their downstream ends showed slight settlement but no misalignment. Some rusting of the metal trash racks was evident. Minor erosion and undercutting around the conduit outlets in the plunge pools of both dams was also observed.

3.1.5 Spillway and Reservoir Capacity

The reservoir storage capacity and spillway discharge capacity of Dam 1 and Dike 1 are insufficient to prevent overtopping during the estimated PMF. The reservoir storage capacity and spillway discharge capacity of Dam 2 are also insufficient to prevent overtopping during the estimated PMF.

3.1.6 Operation and Maintenance

Operation and maintenance are the responsibility of the City of Harlowton, with technical assistance provided by the SCS. There is a formal Operation and Maintenance Agreement, dated 21 April 1966, between the owner and the Soil Conservation Service (see Appendix A), which provides for comprehensive, annual, maintenance inspections of the entire project and for the correction of any deficiencies. From correspondence provided by the Upper Musselshell Conservation District, the most recent inspection appears to have been made in 1977. Several maintenance items currently need attention. These are detailed in paragraph 3.2.

There is no formal plan of action to alert downstream inhabitants or interests in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam overtopping or distress.

2. Eliminate rodent populations on the embankments and repair existing rodent damage.

3. Inspect the entire length of the drawdown and outlet conduits and repair if required.

4. Determine the cause of the hole on the upstream face of Dam 1 and repair as required.

5. Take measures to repair the crack in Dam 2, including measures to prevent the infiltration of surface water.

6. Provide erosion protection for the Dam 2 emergency spillway exit channel to preclude possible embankment damage during high flows.

7. Take measures to insure that the control gates are operated as specified in the Operation and Maintenance Agreement.

8. Install surface monuments to monitor and evaluate slope movements on Dam 2, where surface cracking was observed.

9. Inspect all embankments during and after a period of significant storage in the reservoirs.

10. Conduct and place on file stability analyses of all embankments. The analyses should be performed by a geotechnical engineer experienced in the design and construction of earth dams.

11. Conduct more-detailed hydrologic and hydraulic routing studies for the project to better determine the downstream hazard and required spillway capacities and modify the project as studies indicate.

12. Reinstitute annual maintenance inspections as provided in the Operation and Maintenance Agreement.

13. Establish a program for periodic, comprehensive, safety inspections at no more than 5-year intervals. These inspections should be performed by engineers qualified in the design, construction, operation and maintenance of earth dams.

14. Modify the gate controls so that they may be operated at all reservoir levels.

15. Develop a plan to assure that the Twodot Canal is breached outside of the Jawbone Creek basin during major flood events.

Prior to performing engineering studies and remedial construction, all work should be coordinated with the state of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers, Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix C, "Recommended Guidelines for Safety Inspection of Dams", Washington, D.C., May 1975.

2. U.S. Department of Commerce, Earthquake History of the United States, Publication 41-1, Washington, D.C.

3. U.S. Geological Survey, Earthquake Information Bulletion, Washington, D.C., 1973-1978.

4. U.S. Army Corps of Engineers, Office of the Chief of Engineers, "Wave Run-up and Wind Set-Up on Reservoir Embankments", Engineering Technical Letter No. 1110-2-221, Washington, D.C., November 1976.

5. U.S. Department of Agriculture, Soil Conservation Service, "Average Annual Precipitation, Montana, based on 1941-1970 base period", Bozeman, Montana, 1977.

6. Caprio, J.M., "Average Date of Last Freeze-Montana" and "Average Date of First Freeze-Montana", Folders No. 81 and 82, Cooperative Extension Service, Montana State College, Bozeman, Montana, March 1965.

7. Office of Hydrology, NWS, NOAA, Hydrometeorological Branch, "Interim All-Season Probable Maximum Precipitation Estimates, Missouri River Drainage West of the 105th Meridian," January 1, 1980.

8. U.S. Department of Commerce, Environmental Science Services Administration, Weather Bureau, Probable Maximum Precipitation, Northwest States, Hydrometeorological Report No. 43, Washington, D.C., November 1966.

9. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Users Manual for Dam Safety Investigations, Davis, California, September 1978.

(PHOTO 1) Overview, Jawbone Creek Project.

(PHOTO 2) Dam 1, Upstream face from left abutment.

(PHOTO 3) Dam 1, Crest and upstream face from right abutment.

(PHOTO 4) Dam 1, Hole near low-level inlet.

(PHOTO 5) Dam 1, Downstream face from left abutment.

(PHOTO 6) Dam 1, Conduit outlet and plunge pool.

(PHOTO 7) Dam 1, Looking downstream from maximum section.

(PHOTO 8) Dike 1, Upstream face (water is ponded in a natural depression on the downstream side of the embankment).

(PHOTO 9) Dike 1, Downstream face from right abutment.

(PHOTO 10) Dike 2, Upstream face.

(PHOTO 11) Upper Reservoir, Emergency Spillway, looking upstream from Control Section.

(PHOTO 12) Upper Reservoir, Emergency Spillway, looking downstream from Control Section.

(PHOTO 13) Dam 2, Upstream face from left abutment.

(PHOTO 14) Dam 2, Upstream face from right abutment.
(Note sag in crest.)

(PHOTO 15) Dam 2, Downstream face from below left abutment.

(PHOTO 16) Dam 2, Low-level inlet (identical to that for Dam 1).

(PHOTO 17) Dam 2, Ported riser with gate control (identical to that for Dam 1).

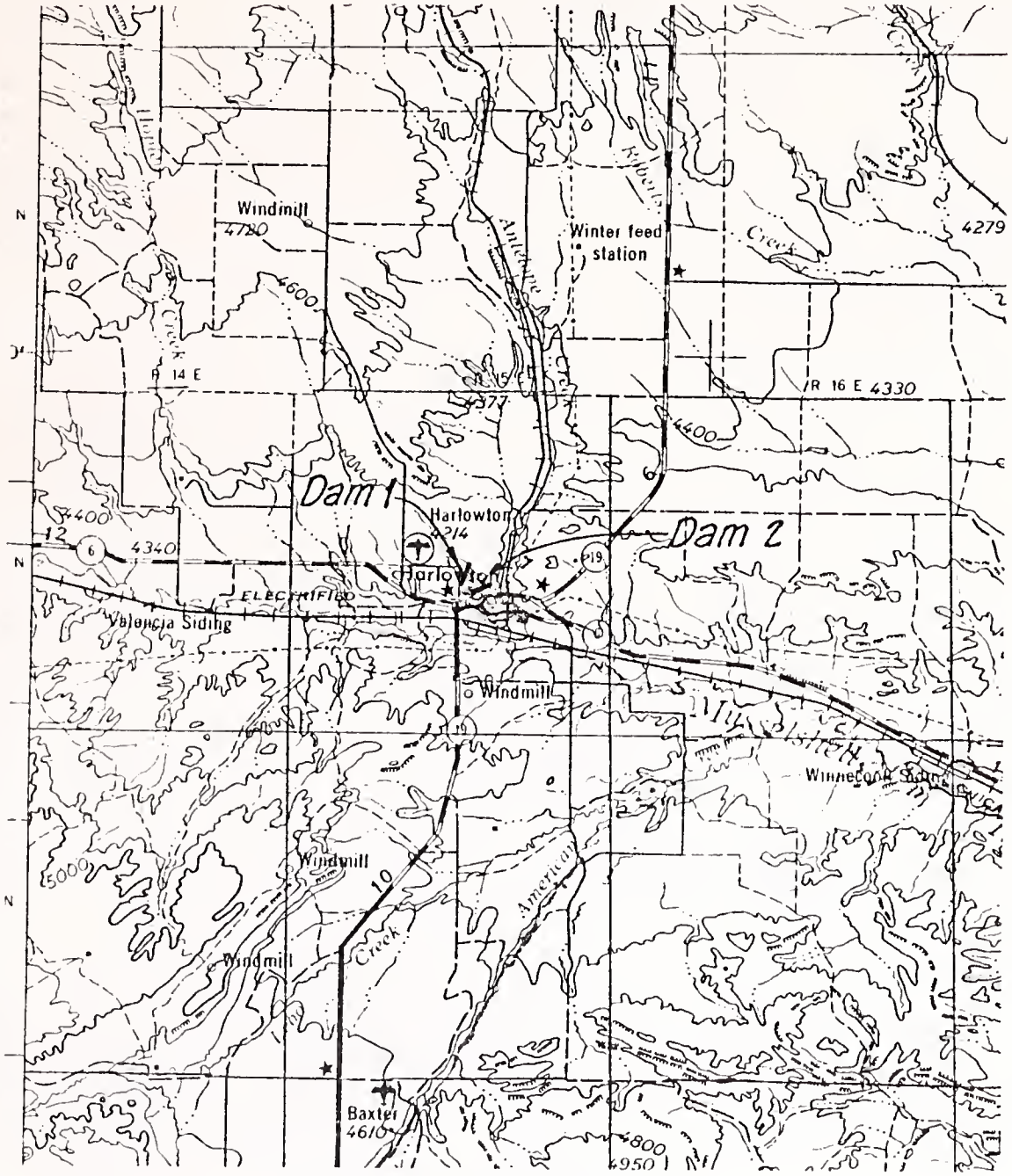
(PHOTO 18) Dam 2, Conduit outlet and plunge pool.

(PHOTO 19) Dam 2, Emergency spillway, looking upstream in approach channel.

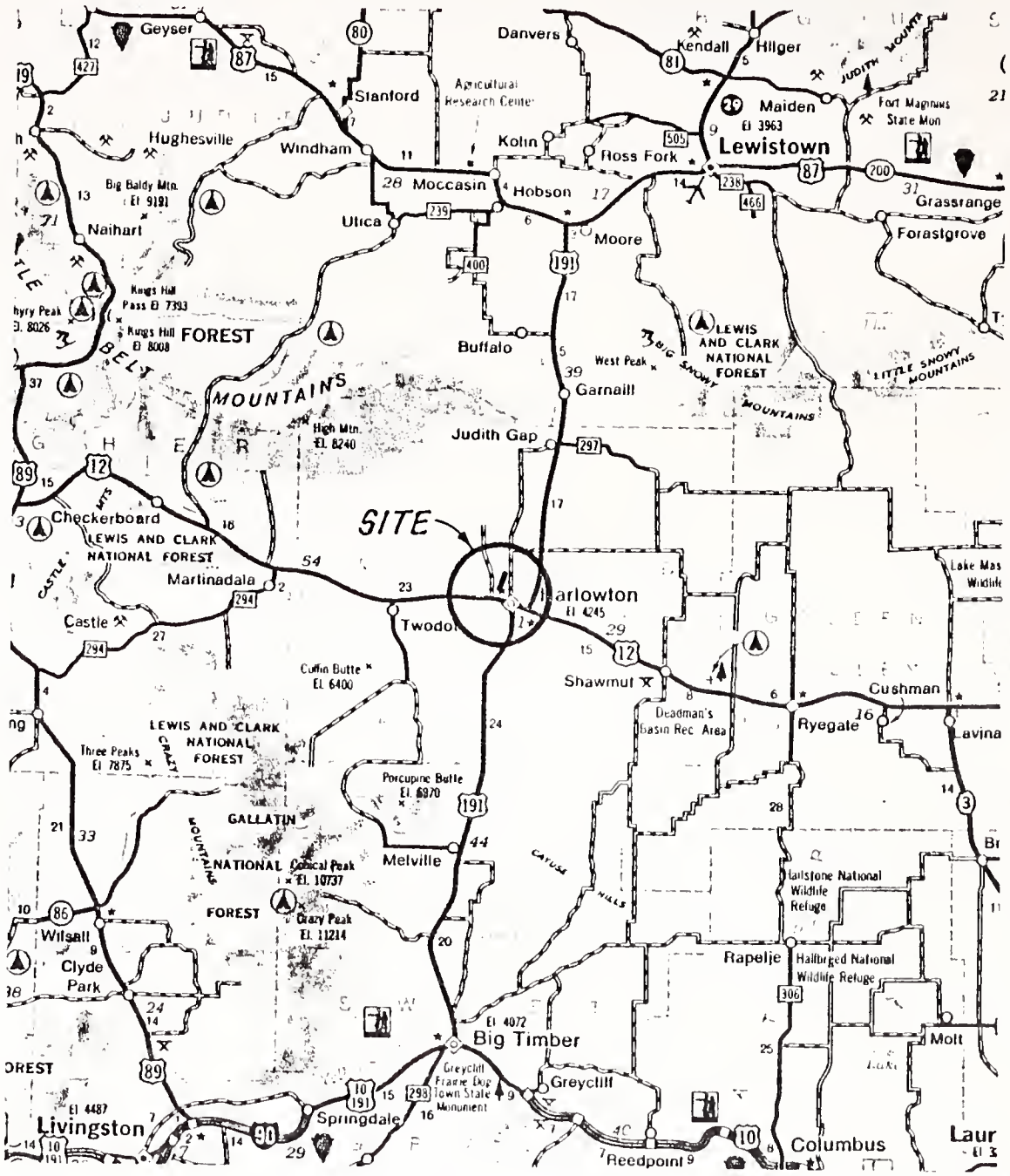
(PHOTO 20) Dam 2, Emergency spillway, control section and outlet channel.

(PHOTO 21) Dam 2, Emergency spillway, looking upstream into outlet channel.

(PHOTO 22) Dam 2, Looking downstream from maximum section.



VICINITY MAP



SITE PLAN

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PLATE 1
JAWBONE CREEK DAMS
SITE PLAN & VICINITY MAP

CROSS SECTION OF DAM NO. 1 - STA. 3+50

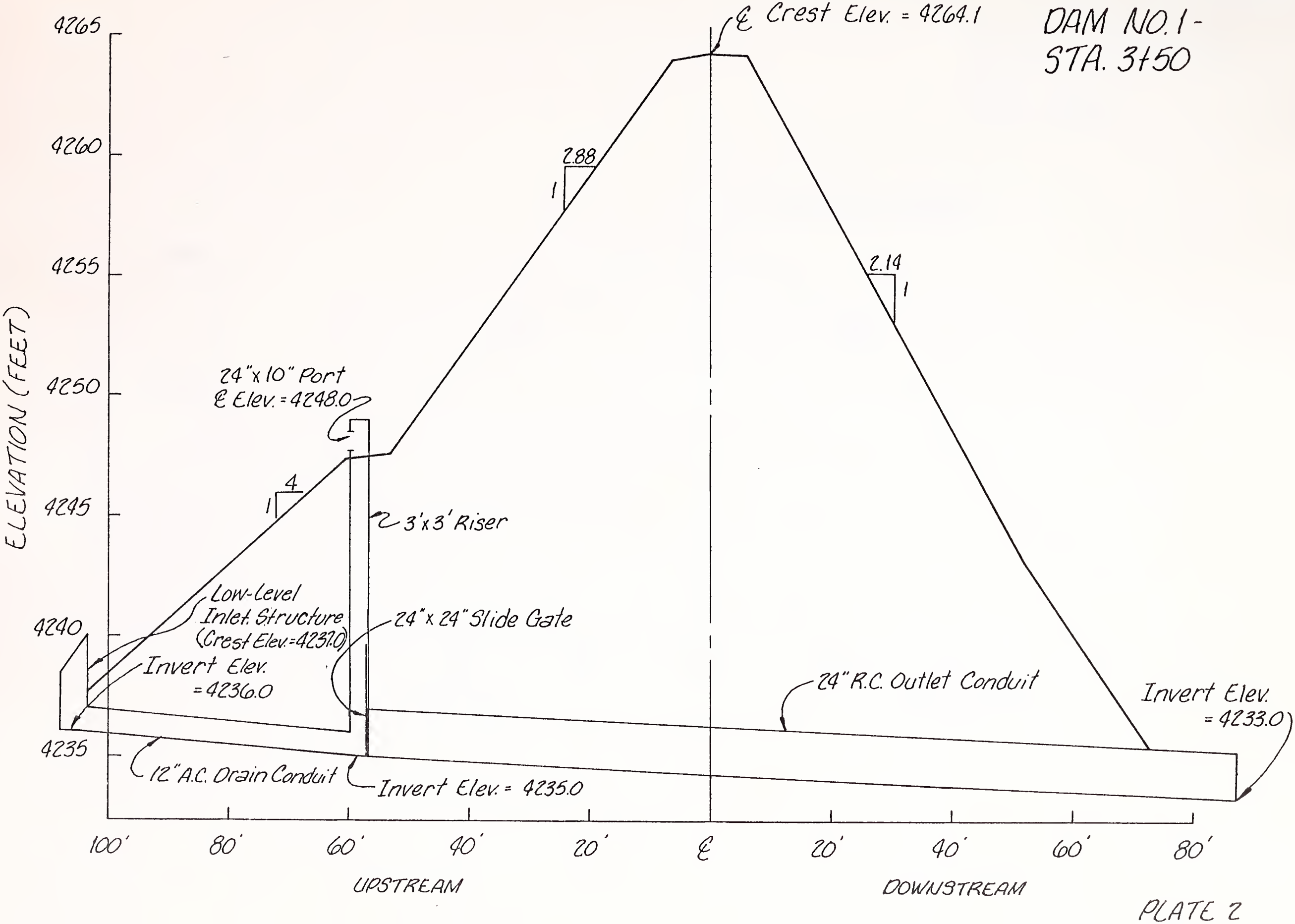


PLATE 2

CROSS SECTION OF
DIKE NO. 1 -
STA. 2+68

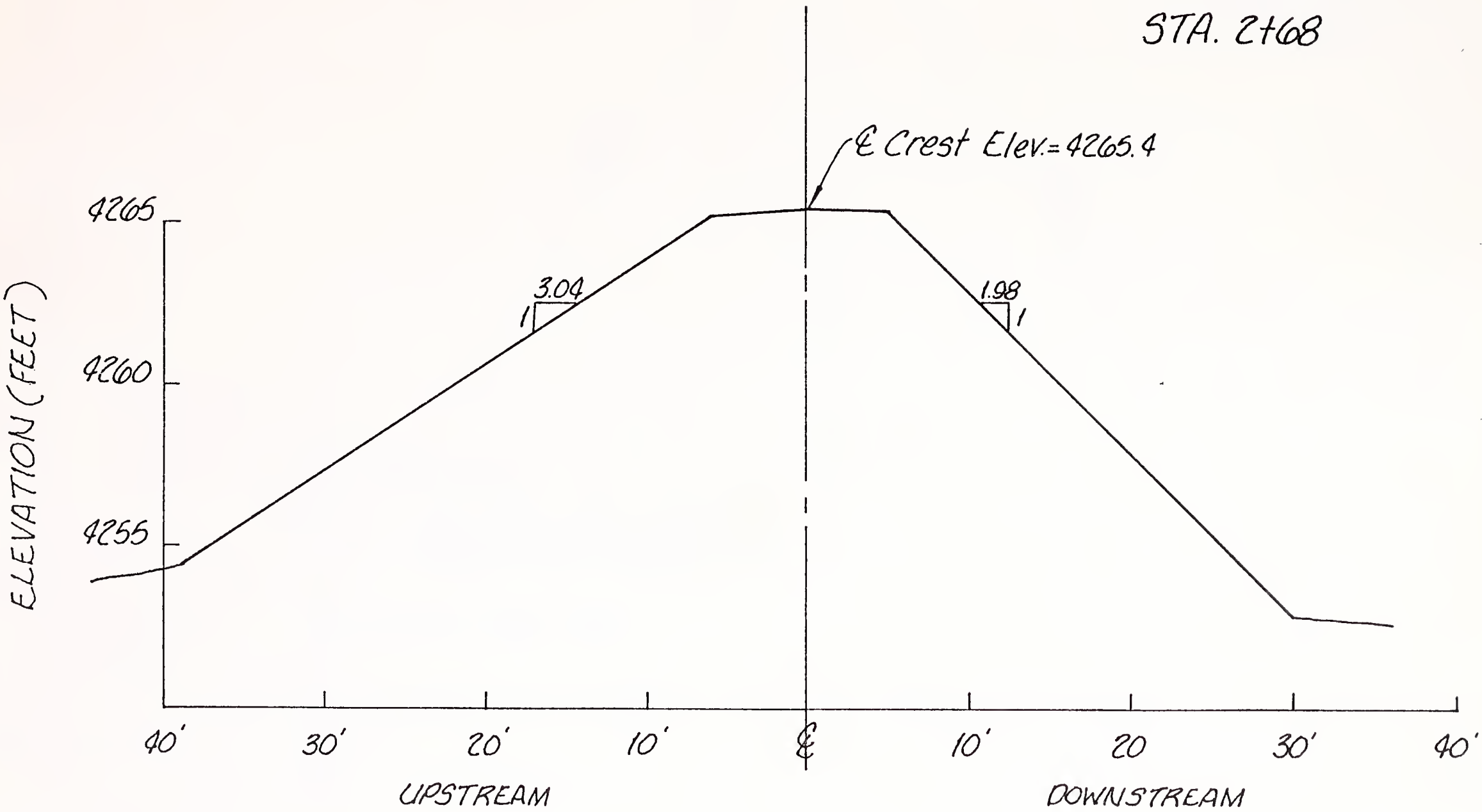


PLATE 3

CROSS SECTION OF DAM NO. 2 - STA. 1+48

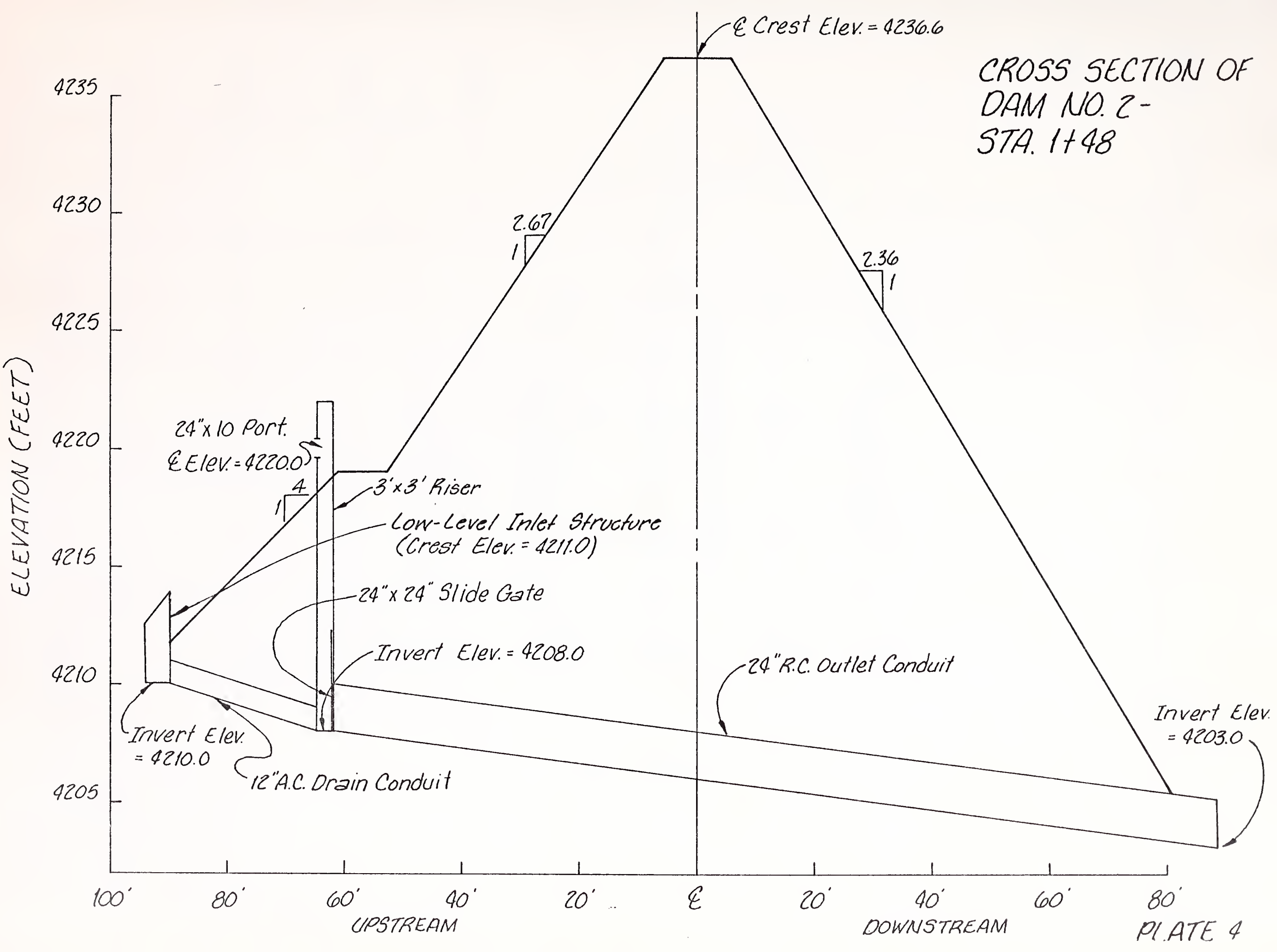
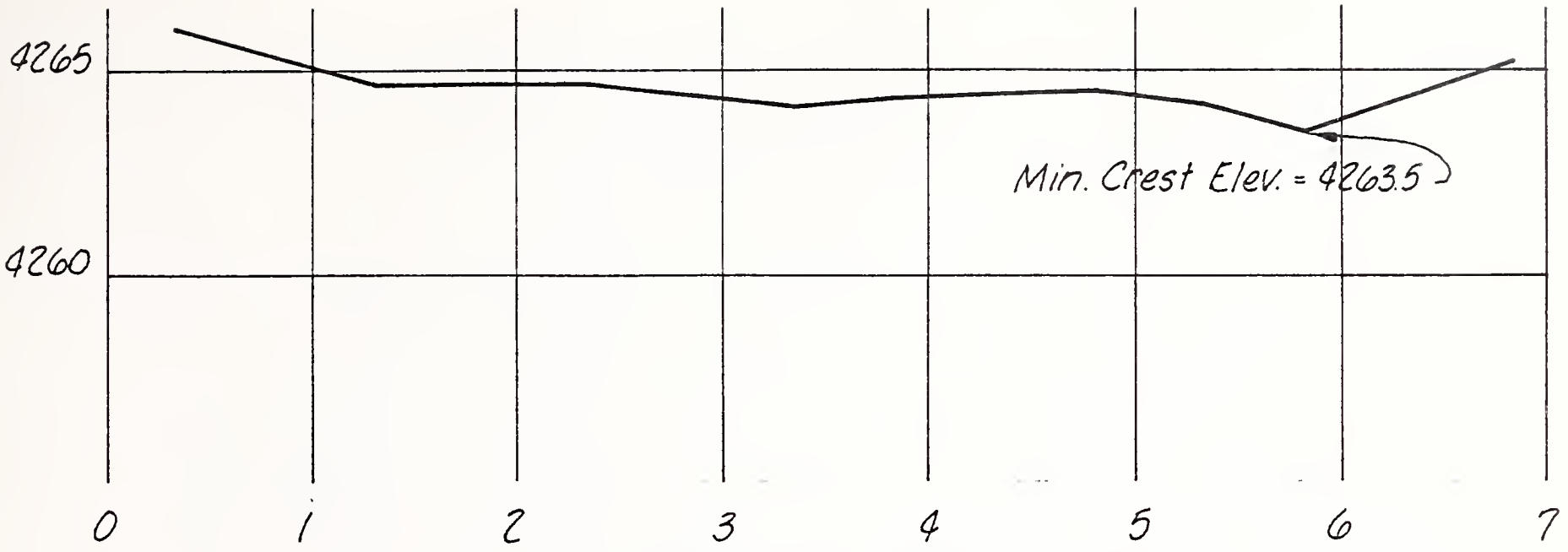
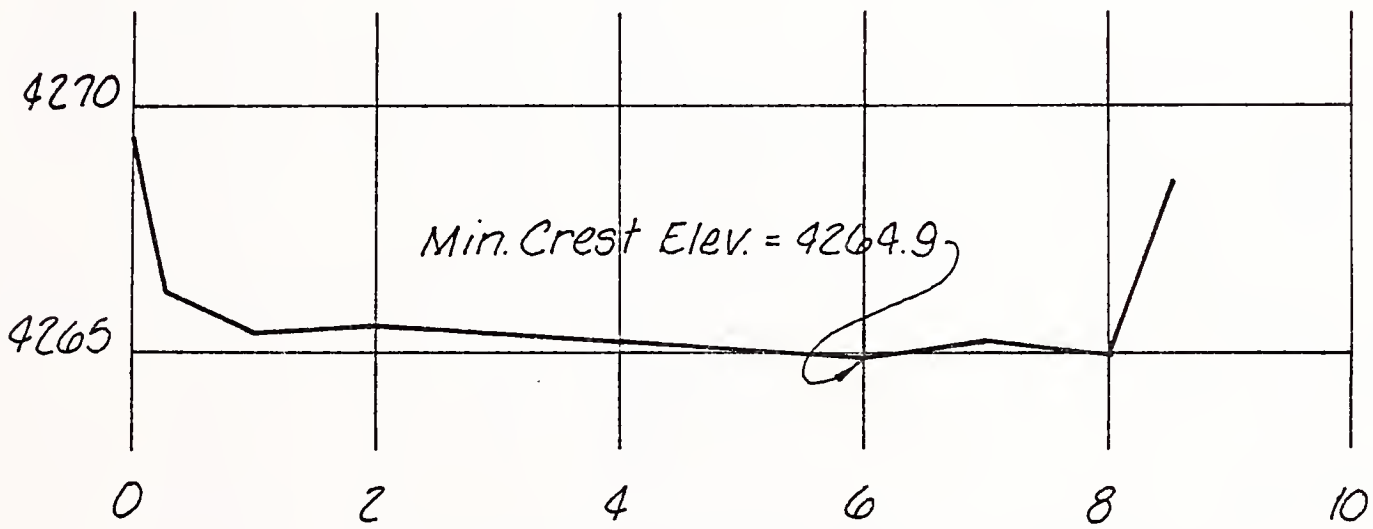


PLATE 4



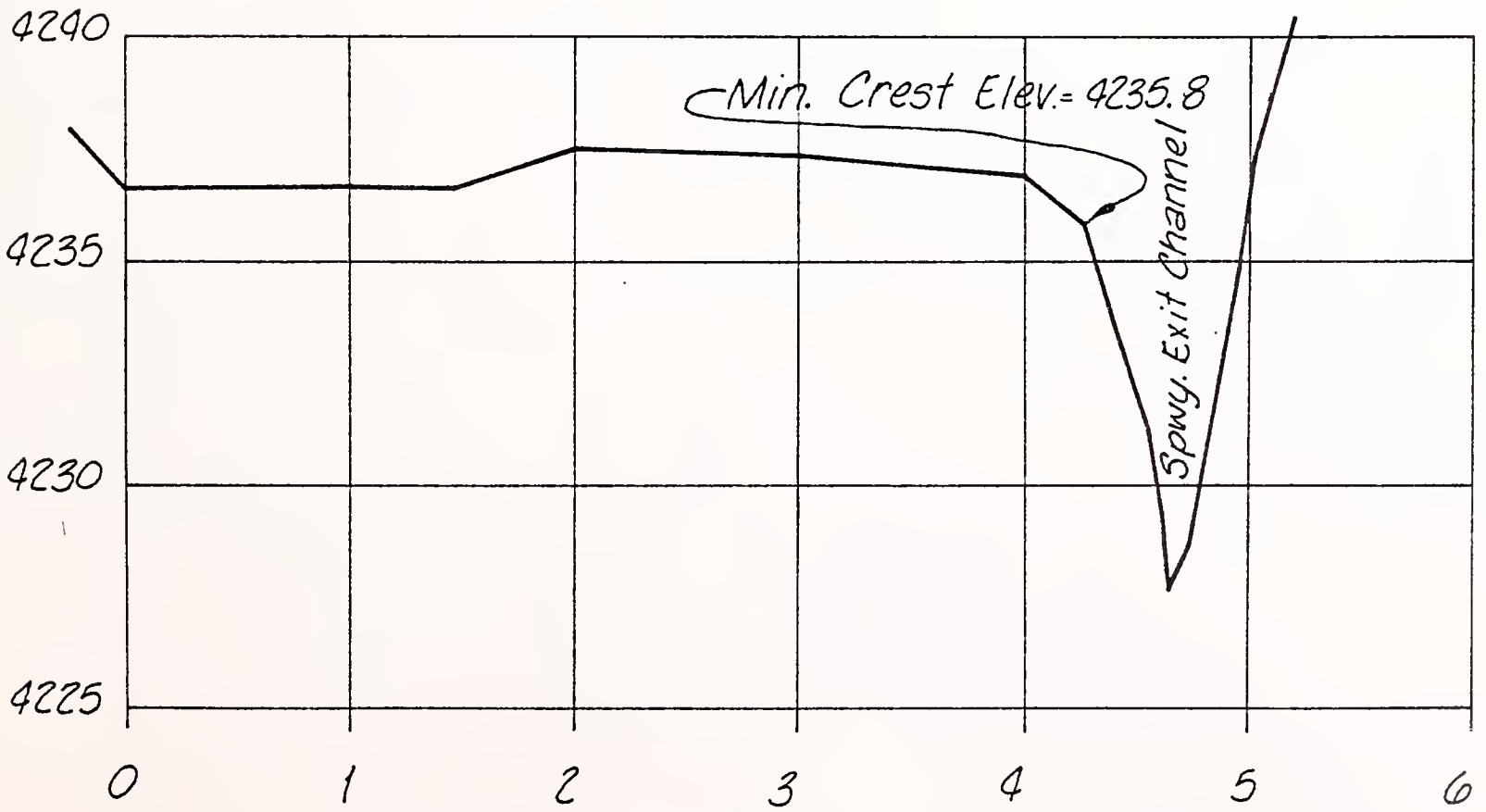
DAM NO. 1-CENTERLINE PROFILE

Scale: 1"=100'H. ; 1"=5'V.



DIKE NO.1-CENTERLINE PROFILE

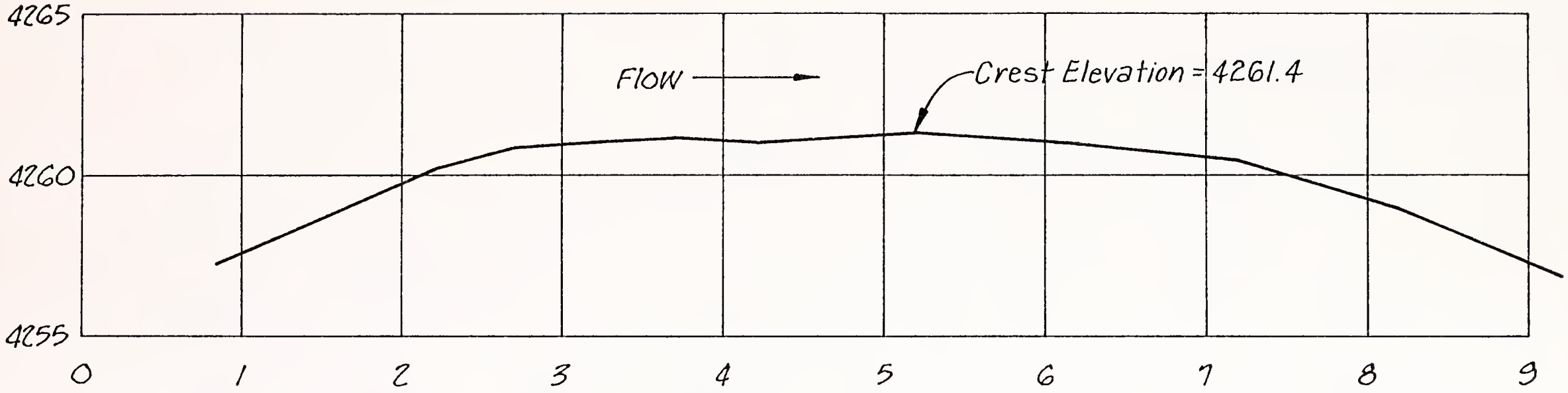
Scale: 1"=200'H. ; 1"=5'V



DAM NO.2-CENTERLINE PROFILE

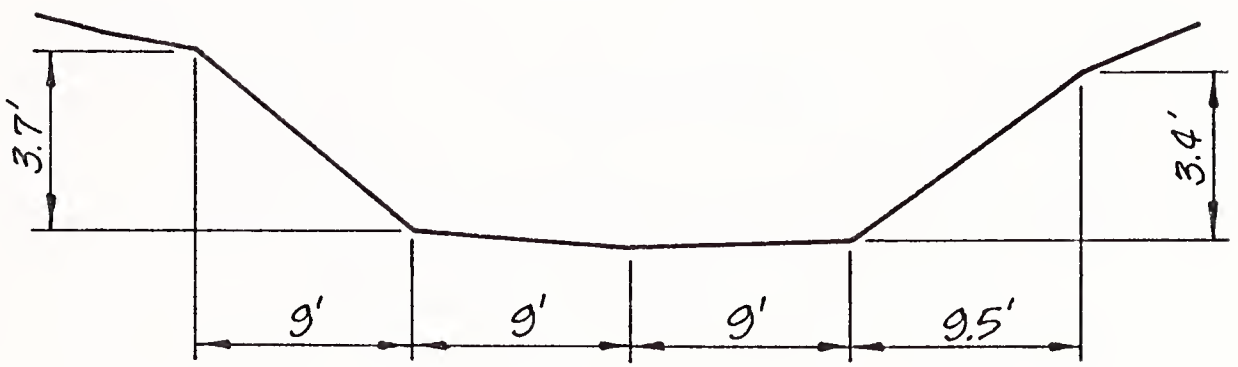
Scale: 1"=100'H; 1"=5'V.

PLATE 5



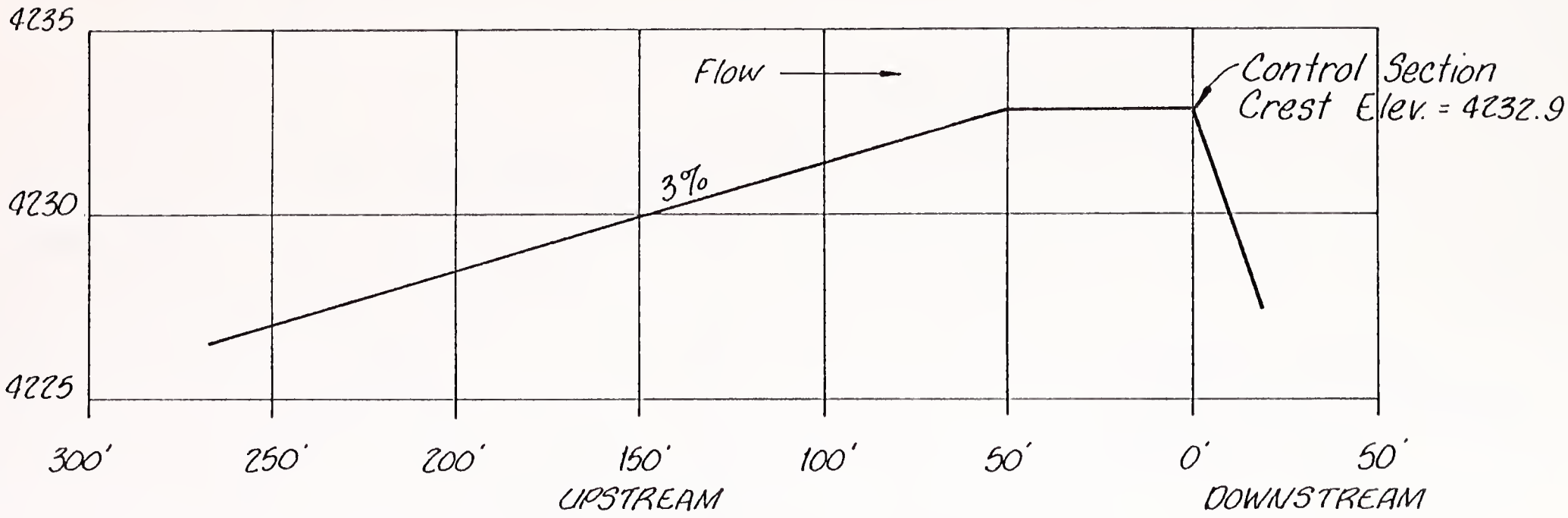
SPILLWAY PROFILE - DAM NO. 1

Scale: 1" = 100' H.; 1" = 5' V.



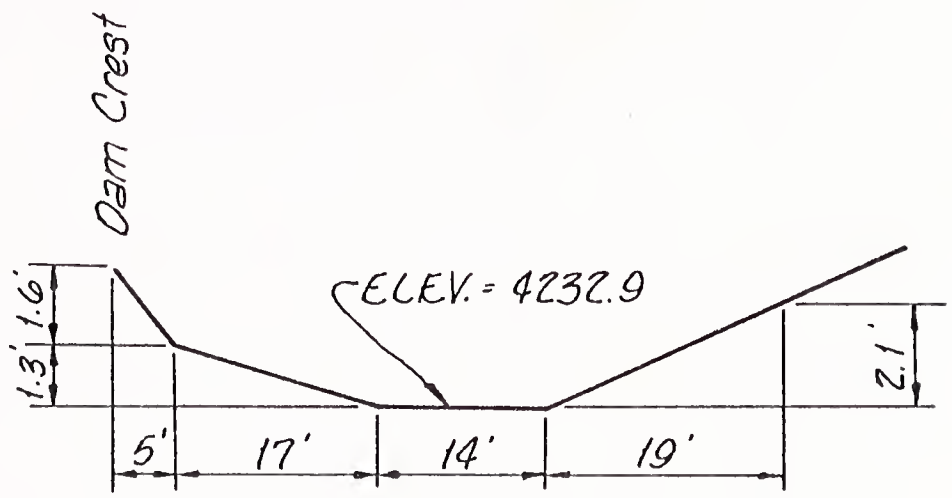
TYPICAL SPILLWAY CROSS SECTION
DAM NO. 1

PLATE 6



SPILLWAY PROFILE - DAM NO. 2

Scale: 1" = 50' H. ; 1" = 5' V.

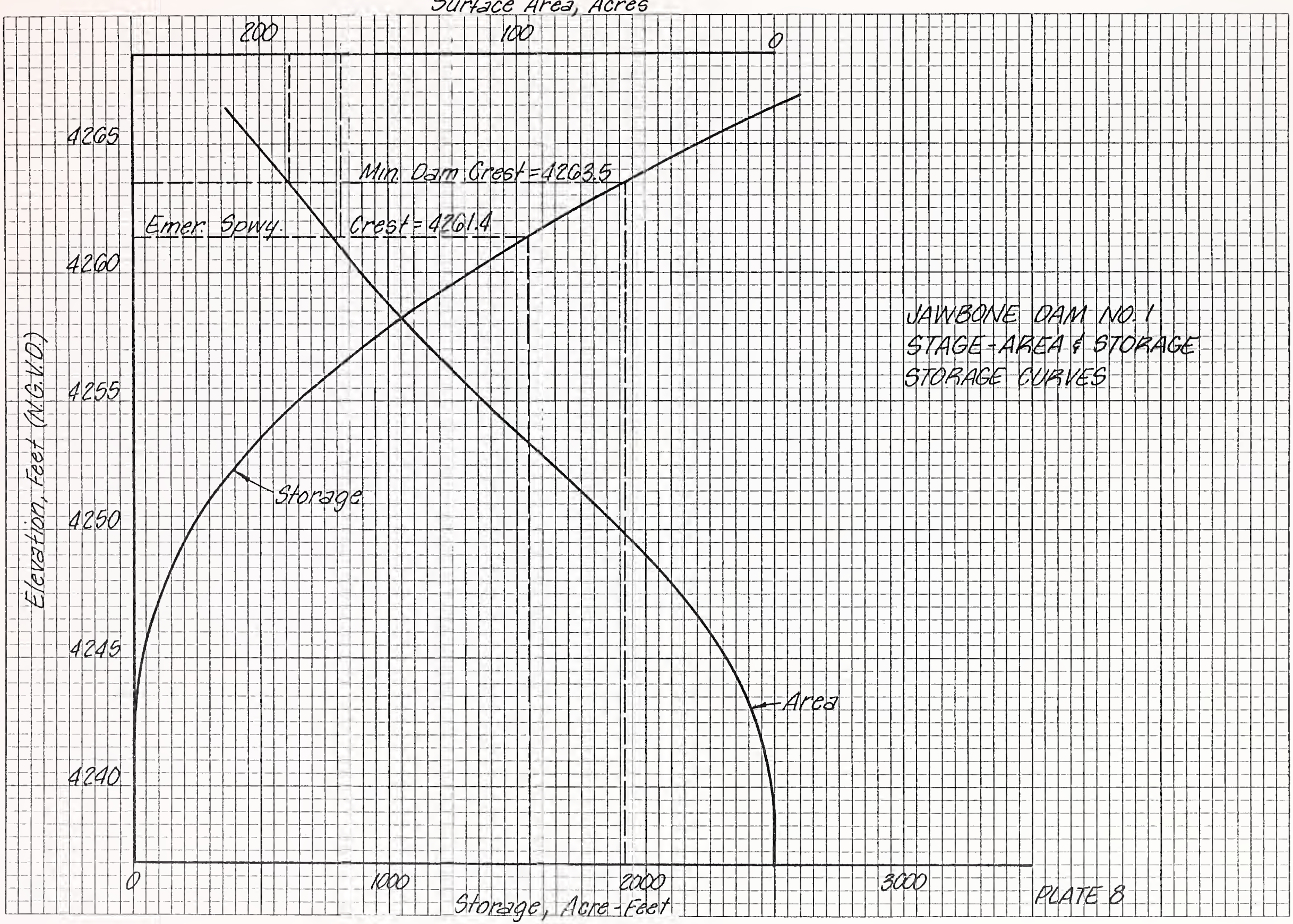


SPILLWAY CROSS SECTION @ CREST
DAM NO. 2

PLATE 7

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0703



JAWBONE DAM NO. 1
STAGE-AREA & STORAGE
STORAGE CURVES

PLATE 8

NO. 10 X 10 PER INCH

Surface Area, Acres

15 10 5 0

Min. Dam Crest = 4235.8

Emer Spwy. Crest = 4232.9

Area

Storage

Elevation, Feet (NGVD)

4235
4230
4225
4220
4215

0 50 100 150

Storage, Acre-Feet

JAWBONE DAM NO. 2
STAGE - AREA & STAGE - STORAGE CURVES

PLATE 9

JAWBONE DAM NO. 1
EMERGENCY SPILLWAY
DISCHARGE RATING CURVE

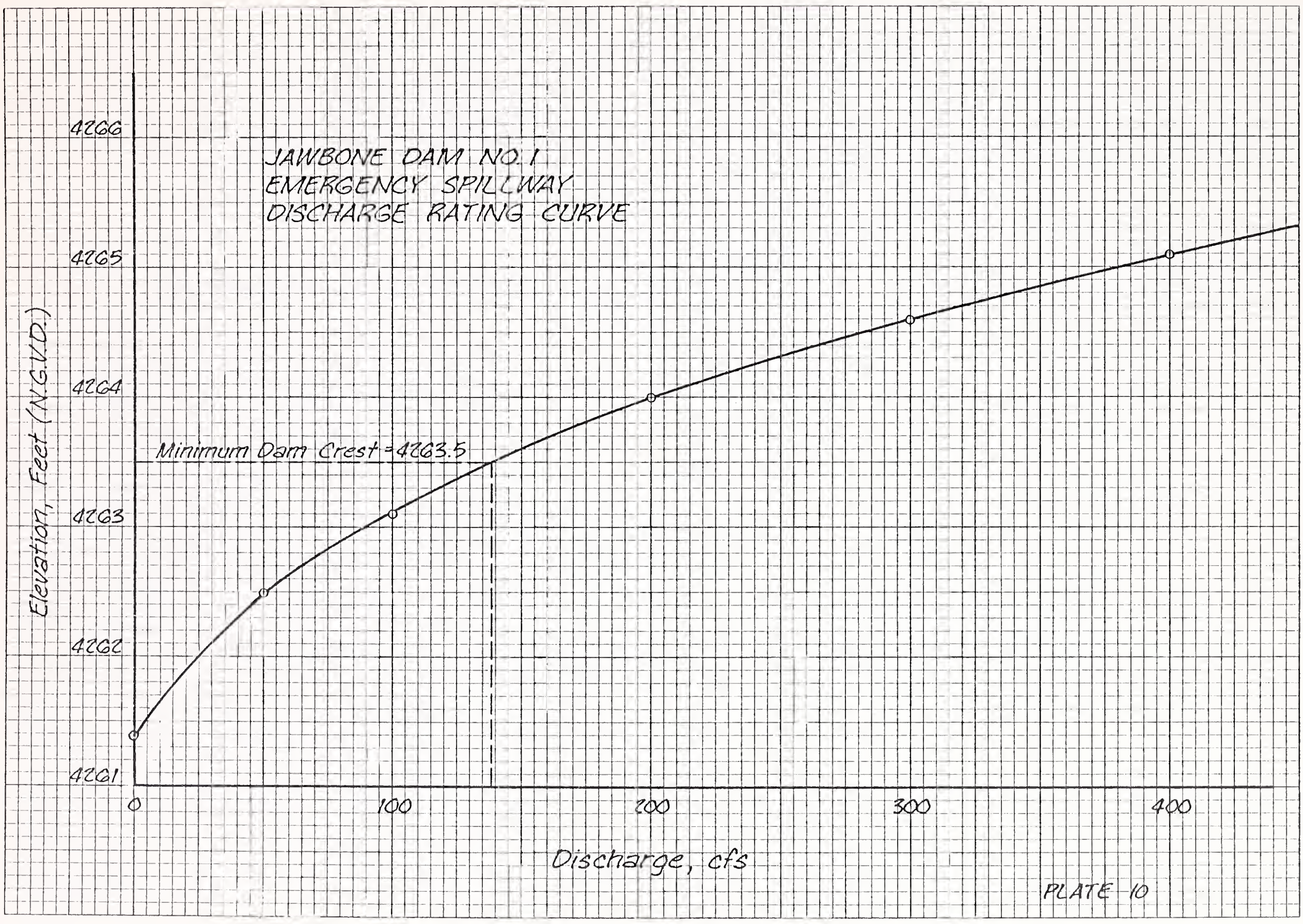


PLATE 10

JAWBONE DAM NO. 2
EMERGENCY SPILLWAY
DISCHARGE RATING CURVE

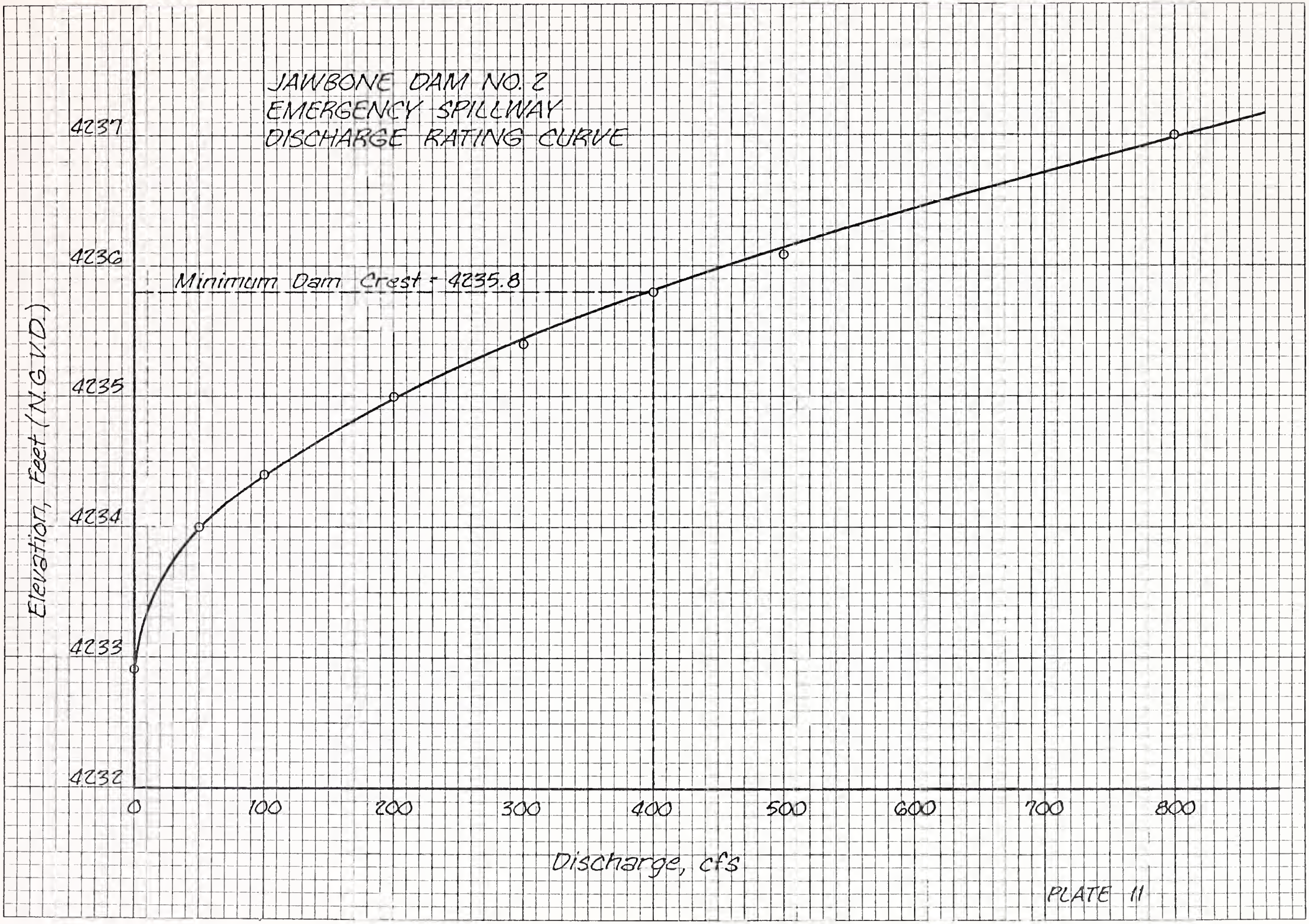


PLATE 11

JAWBONE CREEK WATERSHED

PROTECTION AND FLOOD PREVENTION PROJECT

WHEATLAND COUNTY, MONTANA

PLANS FOR THE CONSTRUCTION OF

FLOOD RETARDING DAMS NO. 1 & NO. 2

AND

FLOOD RETARDING DIKES NO. 1 & NO. 2

INDEX OF DRAWINGS

DRWG NO.	SHT. NO.	TITLE
7-E-20527	1	INDEX OF DRAWINGS
	2	LOCATION MAP
	3	PLAN OF DAM NO. 1 & RESERVOIR
	4	PLAN OF DAM NO. 1 & CROSS SECTION
	5	PROFILE ON ℄ DAM NO. 1 & CROSS SECTION ON ℄ PRINCIPAL SPILLWAY
	6	EMERGENCY SPILLWAY DETAILS
	7	PLAN, PROFILE & CROSS SECTIONS - DIKE NO. 1 & NO. 2.
	8	PLAN OF DAM NO. 2 & CROSS SECTION
	9	PROFILE ON ℄ DAM NO. 2 & CROSS SECTION ON ℄ PRINCIPAL SPILLWAY
	10	EMERGENCY SPILLWAY DETAILS
	11	PRINCIPAL SPILLWAY RISER DETAILS
	12	DRAIN INTAKE, OUTLET CONDUIT & CUTOFF COLLAR DETAILS
	13	CANTILEVER OUTLET & PLUNGE POOL DETAILS
	14	STEEL SCHEDULE
	15	LOG OF TEST HOLES

DESIGN DATA

f'_c = 4000 p.s.i.
f_c = 1600 p.s.i.
f_s = 20000 p.s.i.
n = 8

STRUCTURAL NOTES

1. All exposed concrete edges shall be chamfered 1 inch or rounded.
2. Indicated reinforcing bar spacing is center to center of bars, bar cover is clear distance between surface of bar and face of concrete, and shall be 2" for formed and top surfaces and 3" for surfaces poured against earth, unless otherwise shown.
3. In sections having a single mat of reinforcing, the steel shall be positioned in the center of the section unless otherwise shown.
4. All bar splices not shown on the drawings shall be staggered with bars lapped a min. of 30 dia.

GENERAL NOTES

1. Elevations shown are in feet above mean sea level.
2. All stationing refers to centerline of construction and is the measured horizontal distance.
3. Quantities are for bid purposes only. Contractor will be responsible for furnishing and placing all materials.

PLATE 12

INDEX OF DRAWINGS
JAWBONE CREEK WATERSHED
WHEATLAND COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	BBG,MEH,HS	4-65
Drawn	DHG,JRN,BLL,RVT	4-65
Traced		
Checked		

State Conservation Engineer
Head, [illegible]

Sheet 1 of 15 — 7-E-20527

Watershed Boundary

Watershed Boundary

Reservoir Boundary

17 | 16 | 15
20 | 21 | 22

Airport

21 | 22
28 | 27

Emergency Spillway

Site #1 Reservoir Boundary

Dike #1

Dike #2

Dam #1

Site #2 Reservoir Boundary

Dam #2

Antelope Cr.

15 | 14
22 | 23

T 8 N

U.S. 12

HARLOWTON

U.S. 191

Watershed Boundary

20 | 21
29 | 28

21 | 22
28 | 27

Milwaukee R.R.

22 | 23
27 | 26

U.S. 191

Musselshell River

R 15 E

PLATE 13

LOCATION MAP
FLOOD RETARDING DAMS NO 1 & NO 2
JAWBONE CREEK W.F.P.
WHEATLAND COUNTY MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
Drawn RVT	5-69	Title
Traced		Title
Checked HMH, RVT, MFH, BWS, LP	Sheet No. 2 of 15	Drawing No. T-E-20527

SCS 313C (9-64)

Cemetery

Airport

County Road

U.S. Govt. Cable (Do not disturb)

Borrow Area A

T.H. #103 T.H. #107 T.H. #113 T.H. #106 T.H. #112 T.H. #102 T.H. #109 T.H. #114 T.H. #111 T.H. #131 T.H. #108 T.H. #115 T.H. #104 T.H. #110

T.H. #600 T.H. #601 T.H. #212 T.H. #610 T.H. #611 T.H. #612 T.H. #613 T.H. #608 T.H. #201 T.H. #202 T.H. #203 T.H. #204 T.H. #205 T.H. #206 T.H. #207 T.H. #208 T.H. #213

℄ Emergency Spillway See sht. 6

BM #5 X

Leah Creek

℄ Dam #1 See sht. 4 & 5

Sta 0+00

Match line - See sheet 8

Jamboree Creek

830.0'

920.0'

Cemetery

℄ Dike #1 see sht. 7

℄ Dike #2 see sht. 7

Sta 4+25

Sta 0+00

Sta 0+100

BM #4

BM #3

Note:
All excavated material's from foundation excavations which are to be wasted shall be placed in the area below the downstream toe of the embankment.

Stripping from the borrows shall be stockpiled and spread over borrow excavations.

PLAN OF DAM NO1 - DIKES No.1 & 2 ℄ RESERVOIR

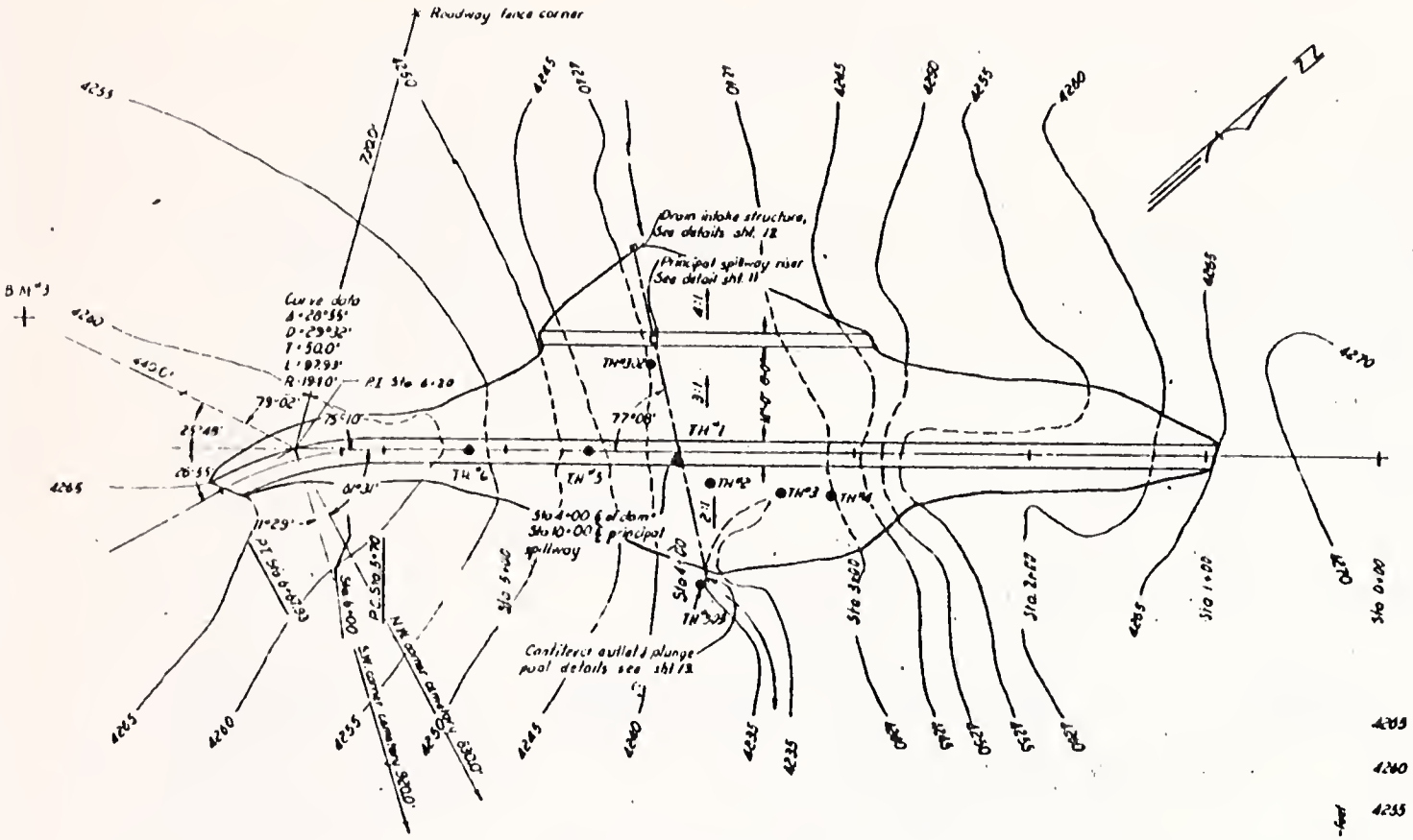
200 0 200 400
Scale in Feet

PLATE 14

PLAN OF DAM & DIKES NO. 1 & 2
FLOOD RETARDING DAM NO1
JAVIECHE CREEK WATERSHED
WHEATLAND COUNTY, MONTANA

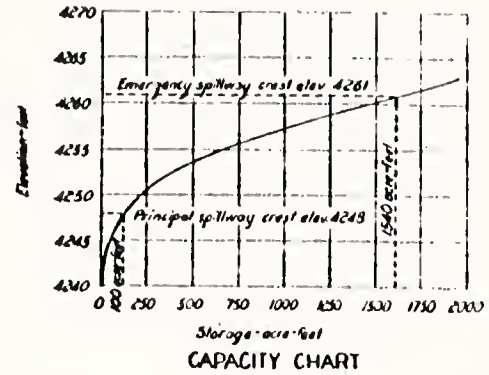
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed B.B.G., R.S., M.E.M.
Drawn B.L.L.
Traced
Checked
Approved by
Title
Date
Sheet No. 3
Scale 1" = 200'
Drawing No. 58-20827

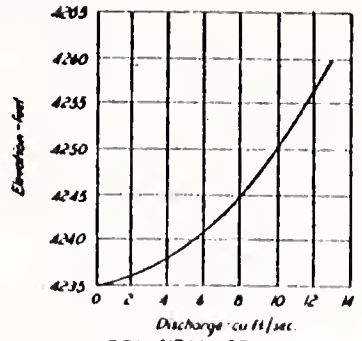


PLAN OF DAM NO.1

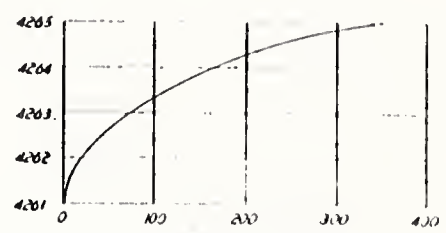
50 0 50 100
Scale in feet



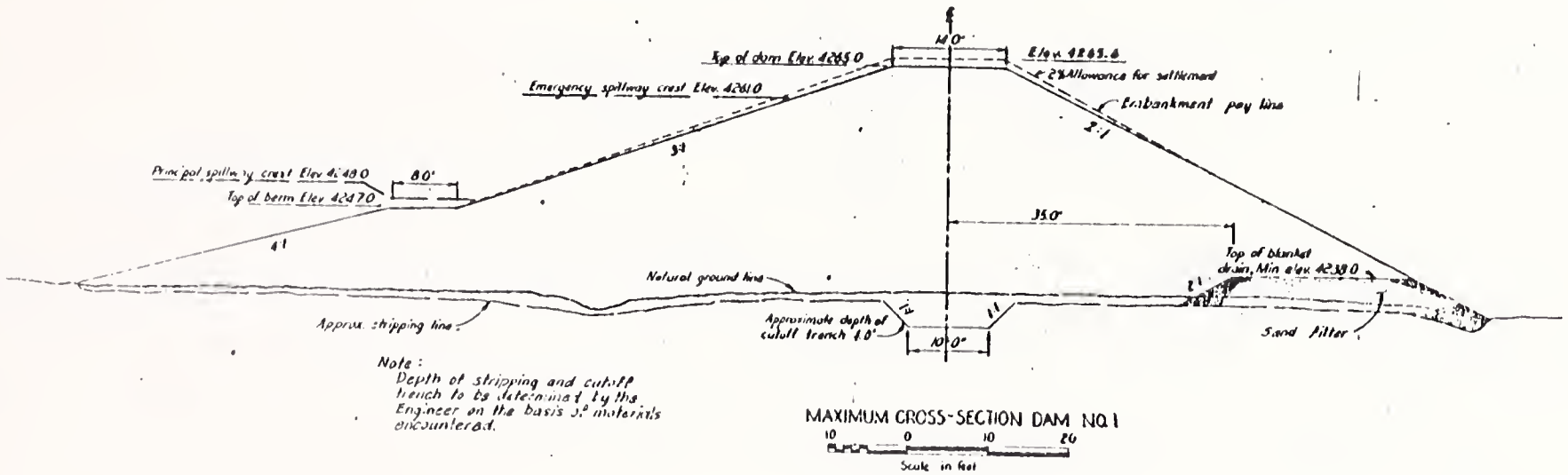
CAPACITY CHART



PRINCIPAL SPILLWAY DISCHARGE CURVE



EMERGENCY SPILLWAY DISCHARGE CURVE



Note:
Depth of stripping and cutoff trench to be determined by the Engineer on the basis of materials encountered.

MAXIMUM CROSS-SECTION DAM NO.1

10 0 10 20
Scale in feet

PLATE 15

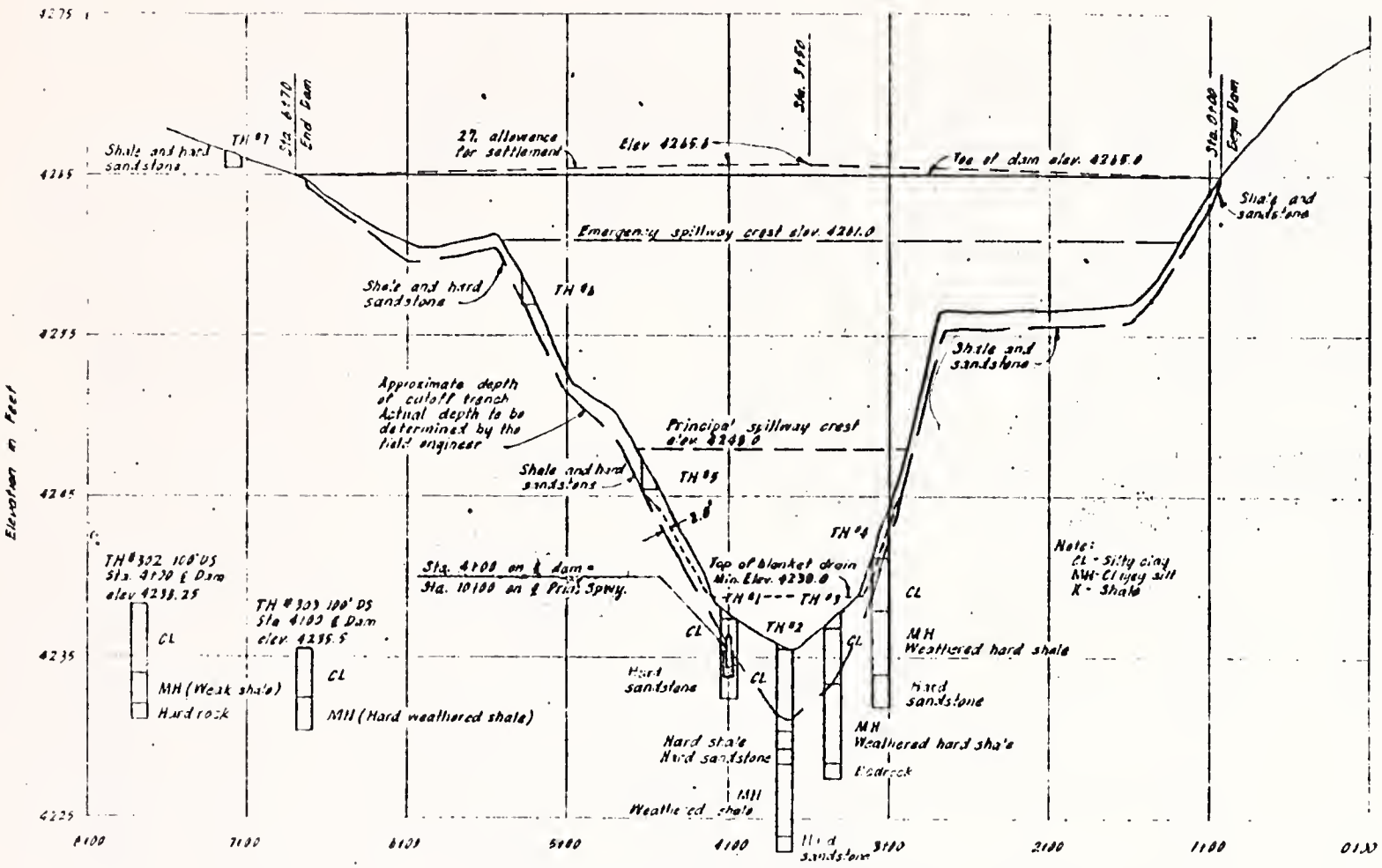
PLAN & CROSS-SECTION
FLOOD RETARDING DAM NO.1
JAWBONE CREEK WPP
WHEATLAND COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

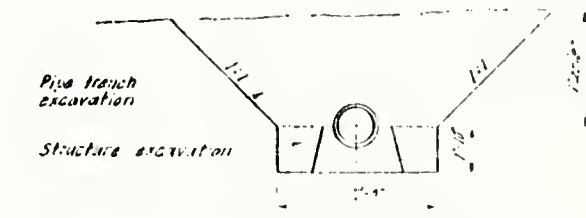
Designed	BBS, RS, MEH	Date	Approved by
Drawn	DHG		Title
Traced			Date
Checked	MEH, RHE, MEH	Sheet No. 4 of 15	Drawing No. 1 E-20527

DAM NO 1 AND DIKES NO. 1 & NO. 2
TABLE OF QUANTITIES

ITEM	QUANTITY	UNIT
EXCAVATION:		
A. Foundation	[illegible]	cu yds
B. Core trench	[illegible]	cu yds
C. Pipe trench	[illegible]	cu yds
D. Emergency spillway (Unclassified)	[illegible]	cu yds
E. Structure, Common	[illegible]	cu yds
F. Structure, Rock	[illegible]	cu yds
▲G. Stripping Base of Dam & Borrow Areas, incl Stockpiling Topsoil	[illegible]	cu yds
2. EMBANKMENT:		
A. Compacted fill,	[illegible]	cu yds
B. Sand-gravel cement [illegible]	[illegible]	cu yds
3. 24" DIA. R/C PIPE, AWWA-C-301	144	lin ft
4. 12" DIA. Asbestos cement pipe, Class [illegible]	48	lin ft
5. CONCRETE, (Class 4000) A. Riser, Drain Intake Cradle, Cutoff Collars Cantilever Support	55	cu yds
6. REINFORCING STEEL	2,356	lbs
7. TRASH RACK: A. Principal Spillway Riser	1	ea
B. Drain Intake	1	ea
8. SLIDEGATE: Class 35-C, 24" x [illegible], gate stem gate stem guides, 2½" hexhead steel lift	1	ea
9. MANHOLE FRAME & COVER: Neenah Foundry Co. Model 1044-A or equal	1	ea

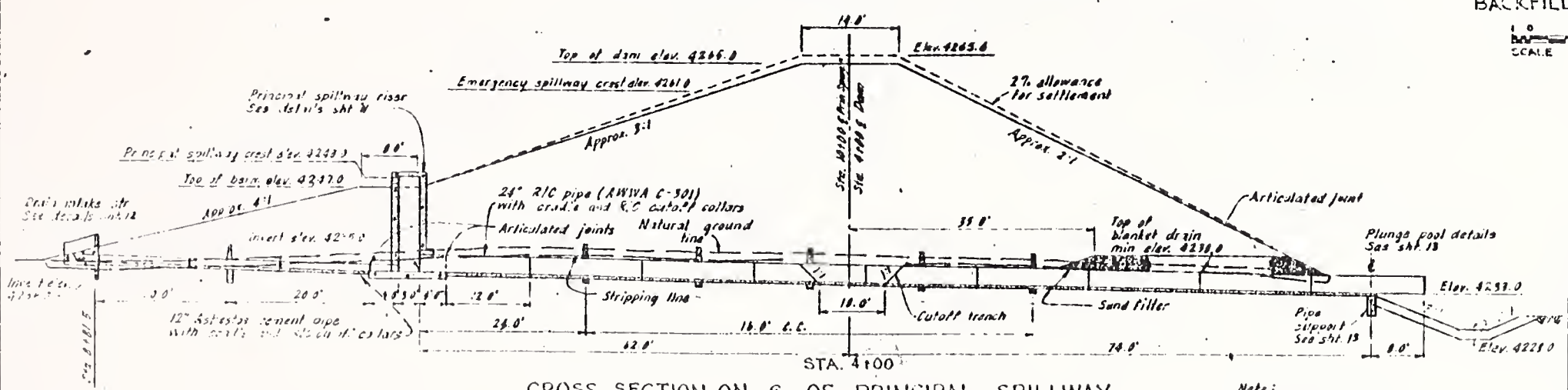


PROFILE ON ℄ OF DAM
(LOOKING UPSTREAM)



CRADLE EXCAVATION & BACKFILL PAY LIMITS

SCALE 1 0 10 IN FEET



STA. 4+00

CROSS SECTION ON ℄ OF PRINCIPAL SPILLWAY

SCALE 10 2 10 30 IN FEET

Note: See sht. 4 for layout and angle between axis of dam and ℄ of pipe.

PLATE 16

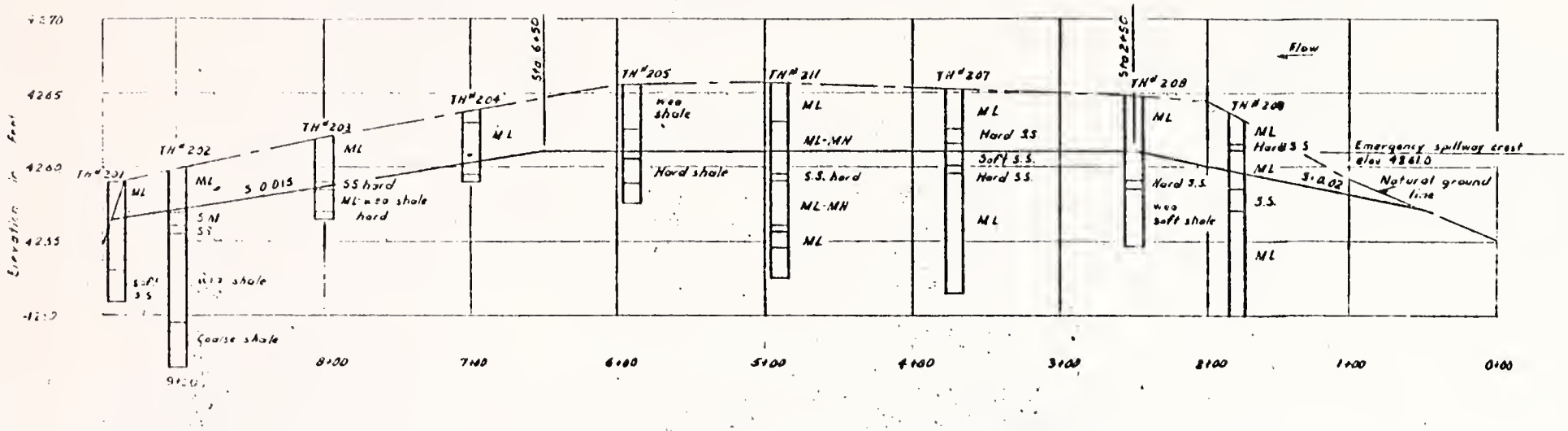
PROFILE & CROSS SECTION
FLOOD RETARDING DAM NO. 1
JAWBONE CREEK WPP
WHEATLAND COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

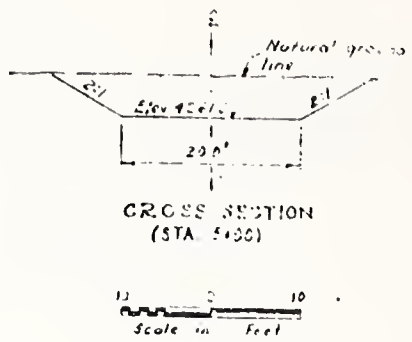
Designed	BBG	Date	Approved by ... Title
Drawn	RVT	Date	Title
Traced		Date	Sheet No. 5 of 15
Checked	[illegible]		Drawing No. 7-E-[illegible]

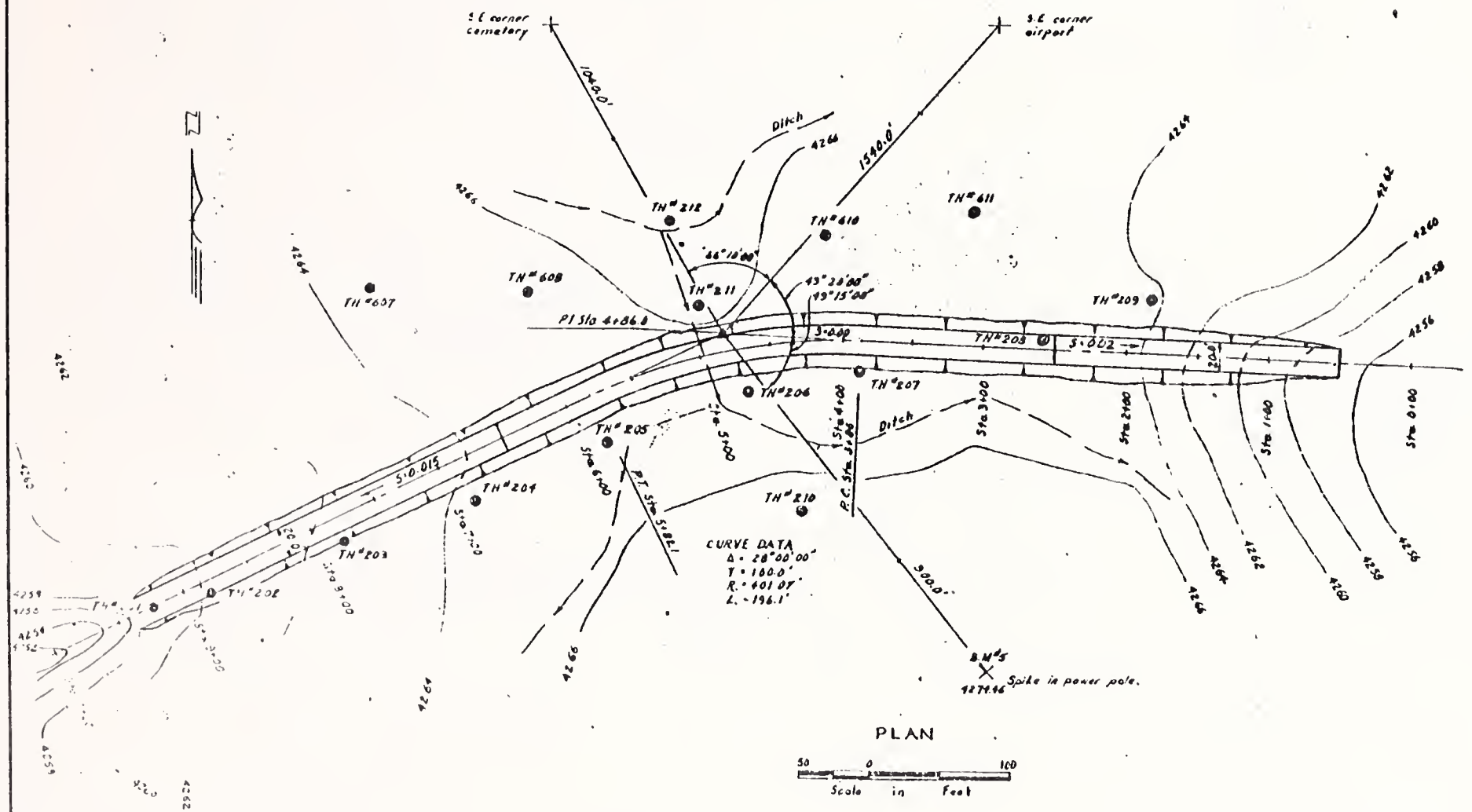
NO.	REVISION	BY
1	Added item "G"	RVT
DATE		

SCS-313C (9-64)



PROFILE ON ℄ EMERGENCY SPILLWAY





Note:
For logs of additional Borings See sht 15

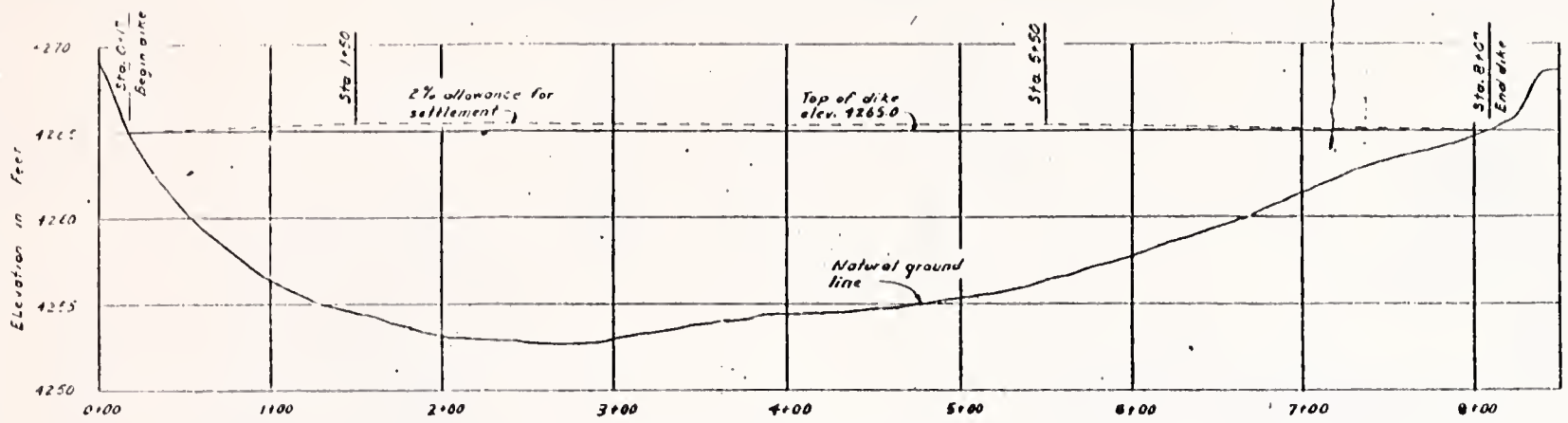
PLATE 17

EMERGENCY SPILLWAY PLAN-PROFILE & CROSS SECTION
FLOOD RETARDING DAM NO. 1
JAWBONE WPP
WHEATLAND COUNTY, MONTANA

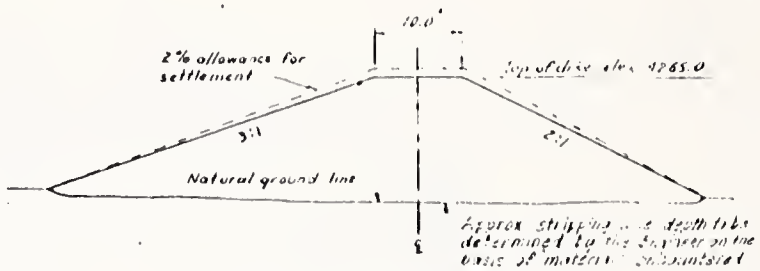
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed B B G, R S	Date 4-65	Approved by	
Drawn J R N.	5-65	Title	
Traced		Sheet No. 16 of 18	Drawing No. [illegible] 1521
Checked JAWS, RTH MEETING			

SCS-313-C (9-64)

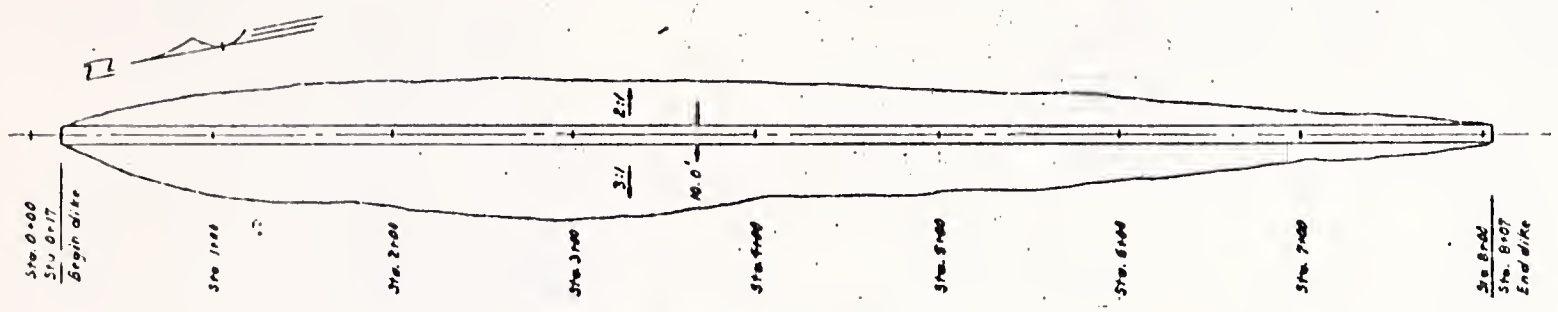


PROFILE ON ℄ OF DIKE NO.1


10.0'
2% allowance for settlement
Top of dike elev. 4265.0
3:1
2:1
Natural ground line
℄
Approx stripping line depth to be determined by the Engineer on the basis of materials encountered

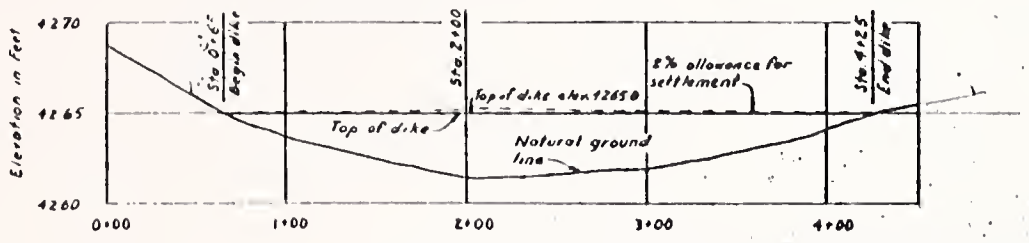
MAXIMUM CROSS-SECTION
DIKE NO.1 (STA 2+00)

10 0 10 20
Scale in Feet

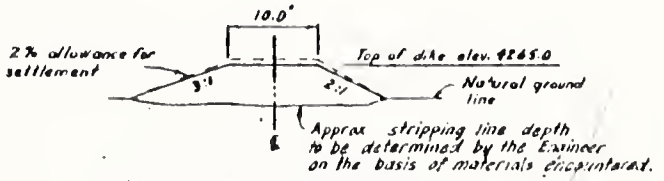


PLAN OF DIKE NO.1

0 50 100
Scale in Feet

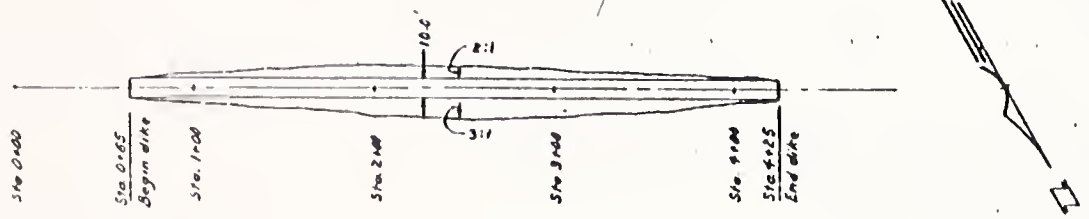


PROFILE ON ℄ OF DIKE NO.2


10.0'
2% allowance for settlement
Top of dike elev. 4265.0
3:1
2:1
Natural ground line
℄
Approx stripping line depth to be determined by the Engineer on the basis of materials encountered

MAXIMUM CROSS-SECTION
DIKE NO. 2 (STA. 2+00)

10 0 10 20
Scale in Feet



PLAN OF DIKE NO.2

0 50 100
Scale in Feet

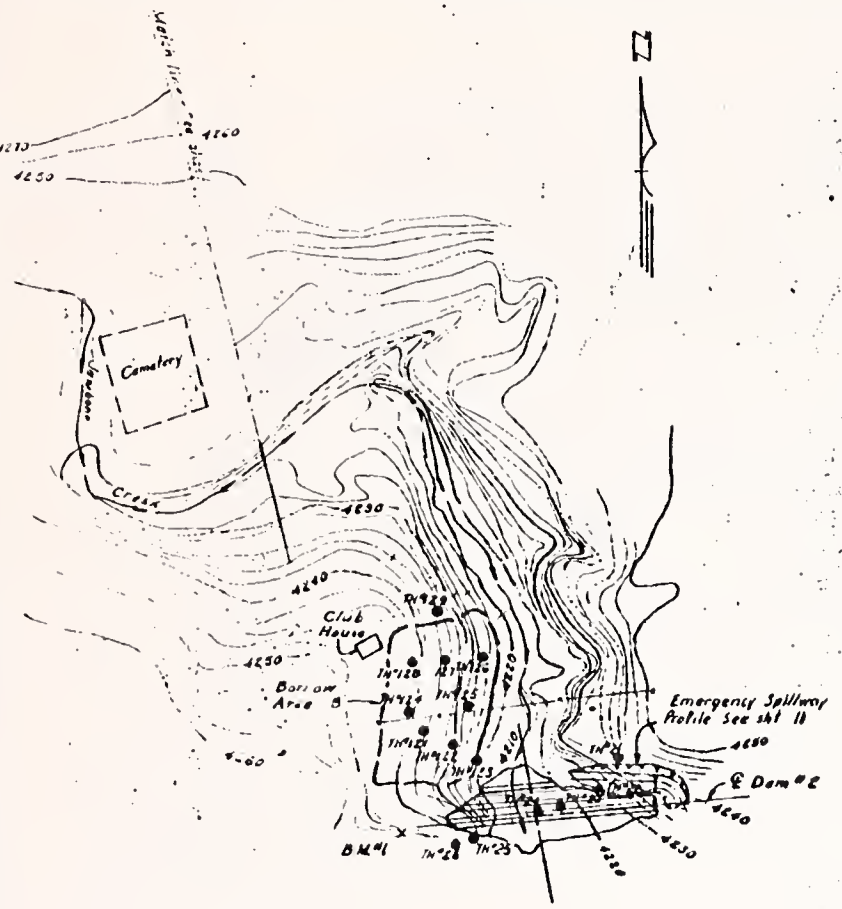
PLATE 18

PLAN, PROFILE & CROSS-SECTION
FLOOD RETARDING DIKES NO. 1 & 2
JAVELINE CREEK WATERSHED
WEATLAND COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

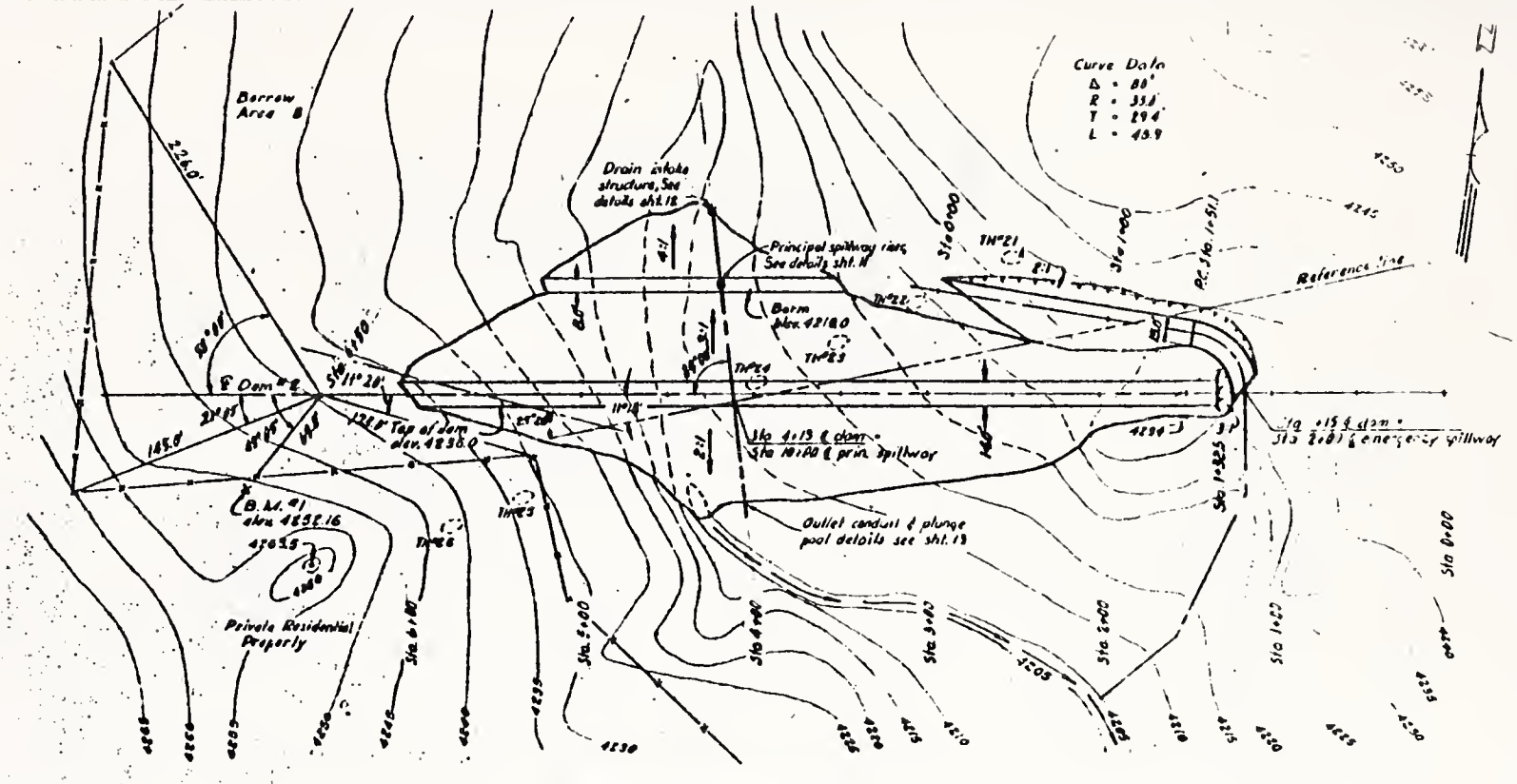
Designed B.D.G. R.S.	Date 4-65	Approved by	
Drawn R.S.	4-65	Title	
Traced J.R.N.	4-65	Title (Sheet)	Drawing No.
Checked [illegible]		No. 7 of 15	SCS-20527

SCS 313C (9-64)



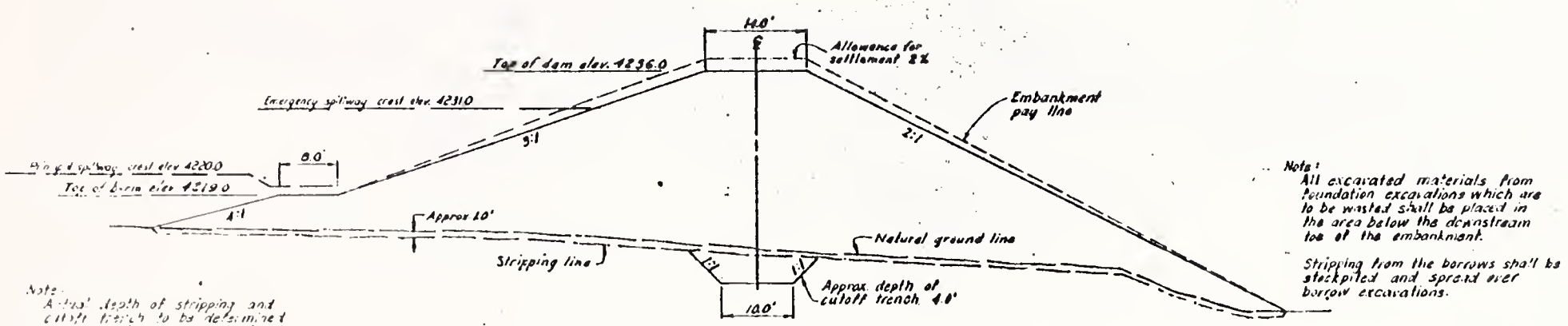
PLAN OF DAM NO.2 & RESERVOIR

200 0 200 400
Scale in feet



PLAN OF DAM NO. 2

50 0 50 100
Scale in feet


14.0'
℄
Top of dam elev. 4236.0
Allowance for settlement 2%
Emergency spillway crest elev. 42310
Principal spillway crest elev. 42200
Toe of berm elev. 42190
8.0'
3:1
2:1
4:1
Embankment pay line
Approx 20'
Natural ground line
Stripping line
Approx. depth of cutoff trench 4.0'
10.0'
Note:
All excavated materials from foundation excavations which are to be wasted shall be placed in the area below the downstream toe of the embankment.
Stripping from the borrows shall be stockpiled and spread over borrow excavations.
Note:
Actual depth of stripping and cutoff trench to be determined by the Engineer on the basis of materials encountered.

MAXIMUM CROSS SECTION OF DAM NO.2 STA.3+07

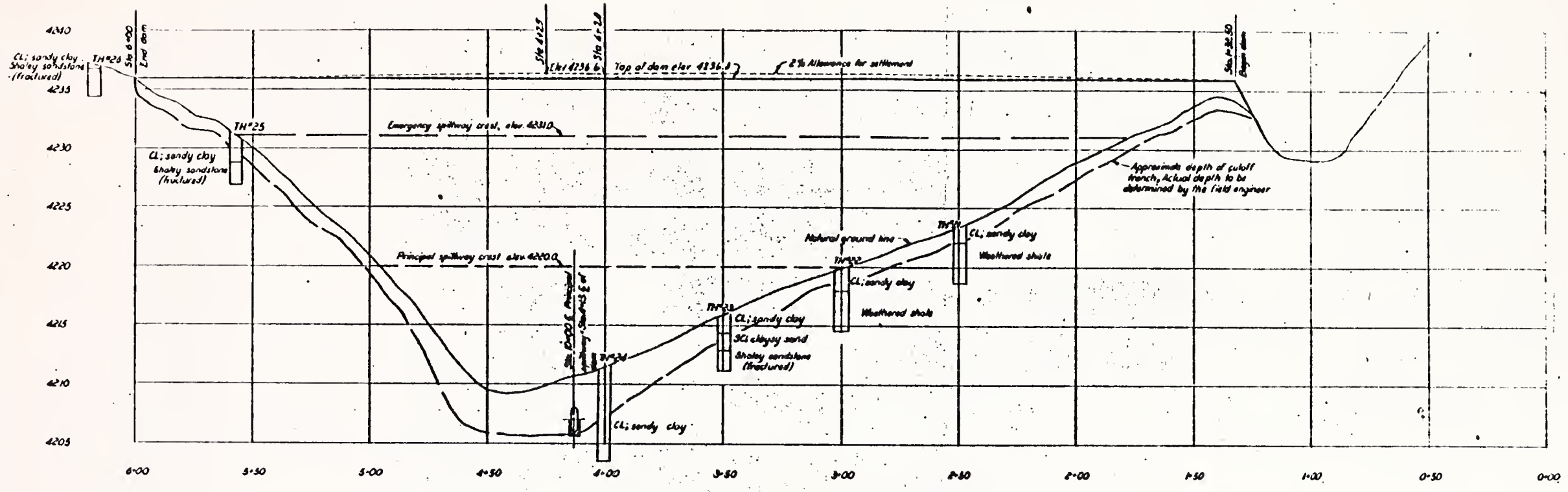
10 0 10 20
Scale in feet

PLATE 19

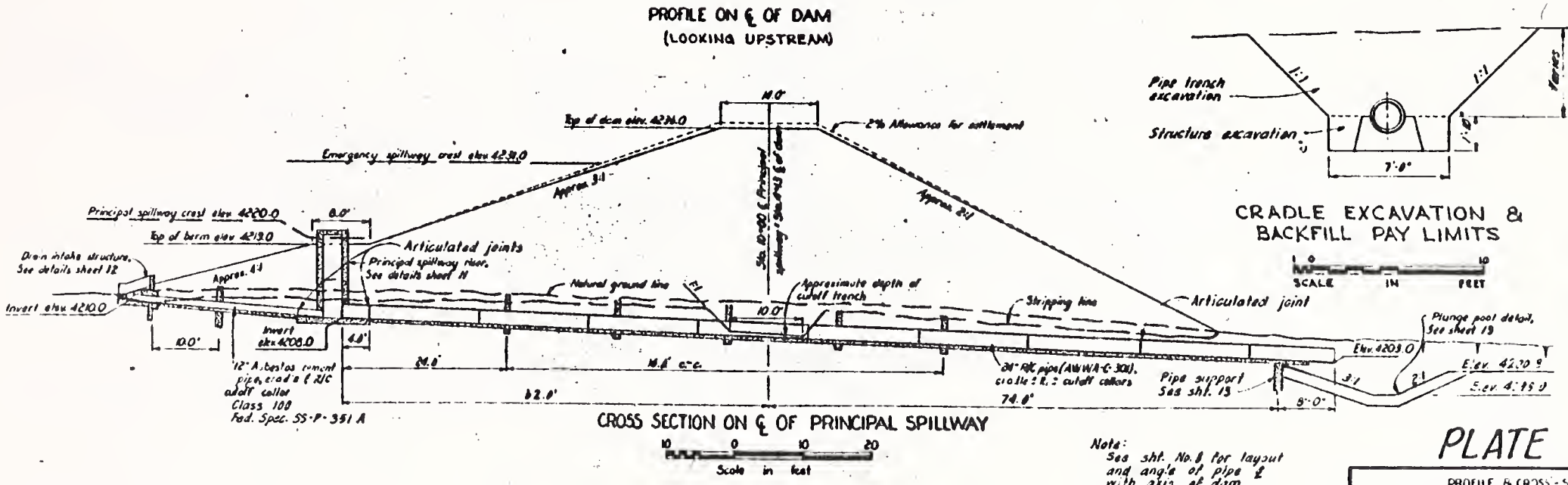
PLAN OF DAM & CROSS SECTION
FLOOD RETARDING DAM NO.2
JAWBONE CREEK WRS
WHEATLAND COUNTY, WYOMING

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed BBG, RS	Date 5-65	Approved by	Title
Drawn B.L.C.	5-65		
Traced			
Checked [illegible]			



PROFILE ON ℄ OF DAM



CROSS SECTION ON ℄ OF PRINCIPAL SPILLWAY

CRADLE EXCAVATION & BACKFILL PAY LIMITS

1 0 10
SCALE IN FEET

Note:
See sht. No. 8 for layout and angle of pipe ℄ with axis of dam.

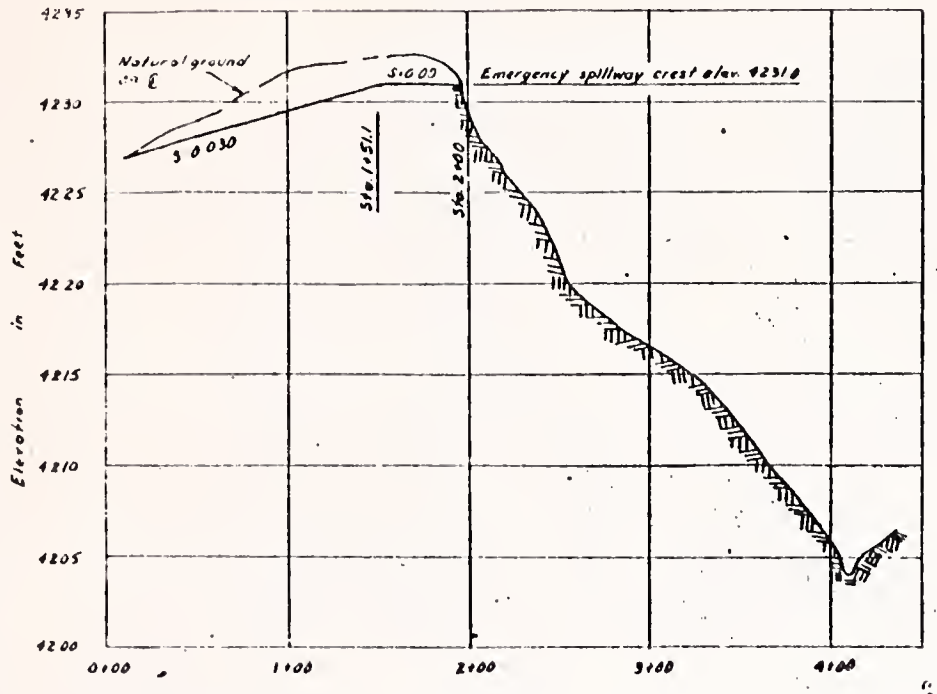
PLATE 20

PROFILE & CROSS-SECTION
FLOOD RETARDING DAM NO 2
JAWBONE CREEK WPP
WHEATLAND COUNTY, MONTANA

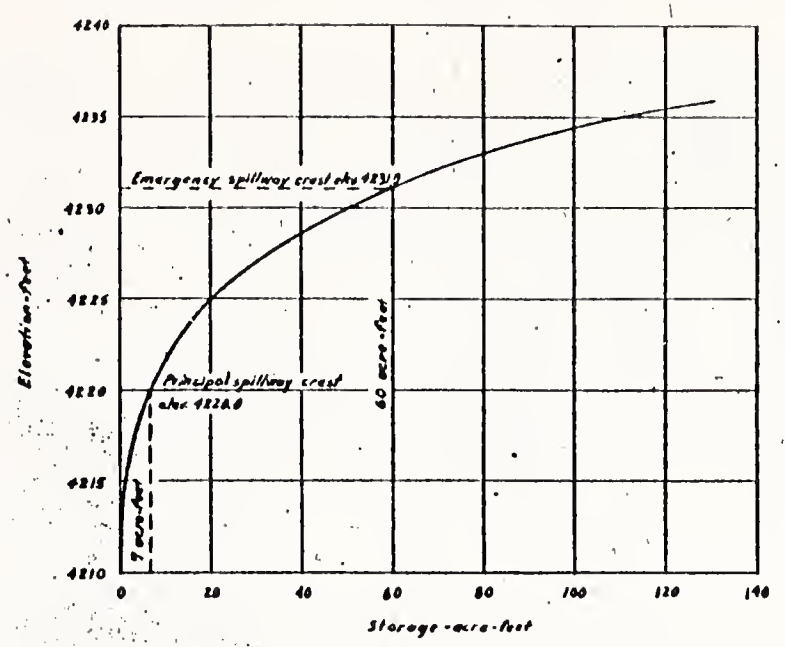
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed BBG, RS, MEH	Date 4-65	Approved by	
Drawn DHG	Date 4-65	Title	
Traced		Title	
Checked [illegible]		Sheet No. 9 of 15 sheets	Drawing No. 7E-30527

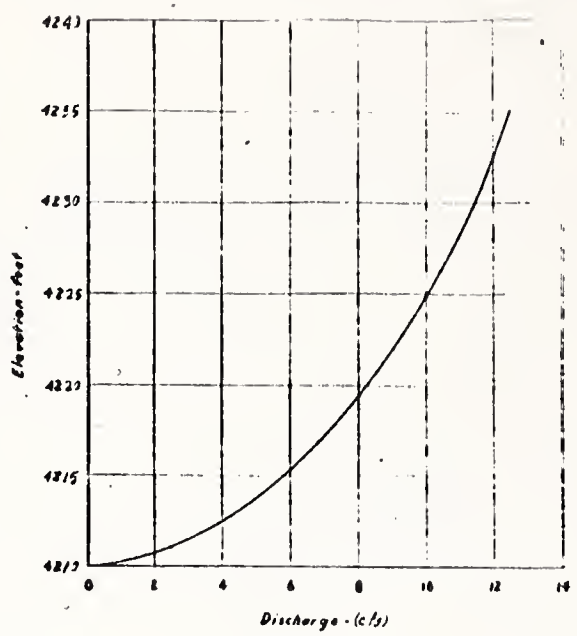
SCS-313C (9-64)



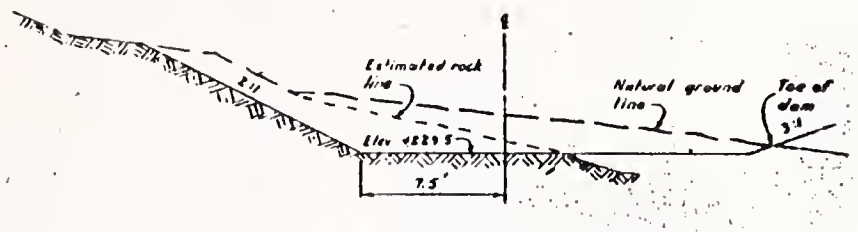
PROFILE ON ℄ OF EMERGENCY SPILLWAY



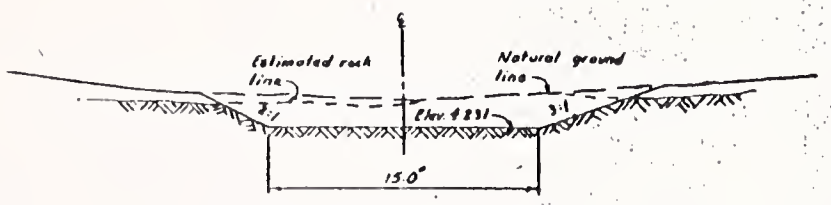
CAPACITY CHART



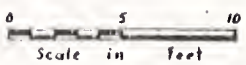
PRINCIPAL SPILLWAY DISCHARGE CURVE



CROSS-SECTION STA. 1+00

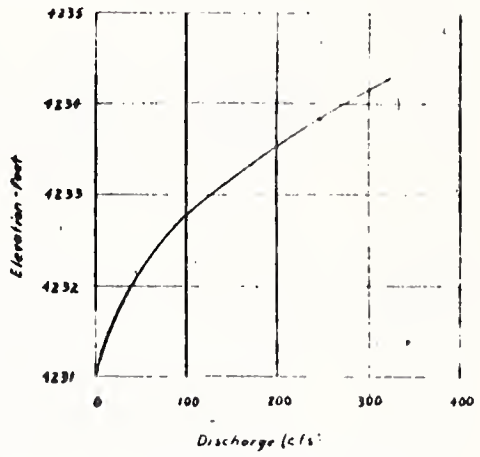


CROSS-SECTION STA. 1+75



DAM NO. 2
TABLE OF QUANTITIES

ITEM	QUANTITY	UNIT
1. EXCAVATION:		
A. Foundation	811	cu. yds.
B. Core trench	673	cu. yds.
C. Pipe trench	296	cu. yds.
D. Emergency spillway	260	cu. yds.
E. Structural Common	61	cu. yds.
F. Structural Rock	21	cu. yds.
▲ G. Stripping, Base of Dam & Borrow Area "B"	1097	cu. yds.
2. EMBANKMENT:		
A. Compacted fill	16,526	cu. yds.
3. 24" DIA. R/C PIPE, ASTM-C-361	146	lin. ft.
4. 12" DIA. Asbestos cement pipe	30	lin. ft.
5. CONCRETE, (Class 4000)		
A. Riser, Drain Intake, Cradle, Cutoff Collars, Cantilever Support	58.6	cu. yds.
6. REINFORCING STEEL:	2,356	lbs.
7. TRASH RACK:		
A. Principal Spillway Riser	1	ea.
B. Drain Intake	1	ea.
8. SLIDEGATE: Class 35-S - 24x24", gate stem gate stem guides, 28" dia handwheel lift	1	ea.
9. MANHOLE FRAME & COVER: Neenah Foundary Co Model 6040-A or equiv.	1	ea.



EMERGENCY SPILLWAY DISCHARGE CURVE

PLATE 21

DATE	REVISION	BY
1-16-64	▲ Added item "G"	F.V.T.

EMERGENCY SPILLWAY PROFILE & CROSS SECTION
FLOOD RETARDING DAM NO. 2
JAWBONE CREEK WATERSHED
WHEATLAND COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed B.B.G., M.E.H. Date 1-'65
Drawn J.R.N. 1-'65
Traced
Checked M.E.H. RECOMMENDED 1-'65
Approved by
Title
Title
Sheet No. 12 of 15
Drawing No. 4-T-1-20-27

SCS 313-C19-64

TOP FACE

BOTTOM FACE

Neenah Model R-6044-A or equiv.

24" max hole and cover

24" dia handwheel lift

Ladder see details

SEC. A

SEC. B

SEC. C

SEC. D

TOP FACE

BOTTOM FACE

PLAN - FOOTING

1-5" x 10" anchor bolts

2" dia. pipe

DETAIL A

D.S. ELEVATION

U.S. ELEVATION

Single ladder rung to be embedded in wall

Detail A

24" dia. handwheel lift

Elev. 6

Elev. B

Trash Rack see details

Thread top 30"

Adjustable stem guide

Construction joint

Bronze stem dia. 12" stem length 12'-0"

24"x24" slide gate Class 35-5

14" R/C pipe AWWA C301

12" Asbestos cement pipe

Elev. A

LONGITUDINAL SECTIONAL

24" dia handwheel lift (Not shown)

Neenah Model R-6044-A or equiv.

Slide gate Class 35-5 (not shown)

Note: Slide gate supplier to provide detail drawings for mounting slide gate and lifting device.

Cut reinforcing bars 2" from manhole frame and 2" from finished face of part.

TRANSVERSE SECTION

LADDER DETAIL

PLAN

FRONT VIEW

SIDE VIEW

TRASH RACK

8"x b" steel plate

Roughen joint

CONSTRUCTION JOINT

SCALE IN FEET

LOCATION	ELEV. A	ELEV. B	ELEV. C	D
Dam #1	4835.0	4846.0	4849.0	13'-6"
Dam #2	4188.0	4200.0	4203.0	12'-0"

PLATE 22

PRINCIPAL SPILLWAY DETAILS

FLOOD RETARDING DAM NO 1 & NO 2

JAWBONE CREEK W.P.P.

WHEATLAND COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed M.E.H. Date 4-65

Drawn D.E.W. 5-65

Traced

Checked M.E.H. R.H.A. McKEAN 5-65

Approved by

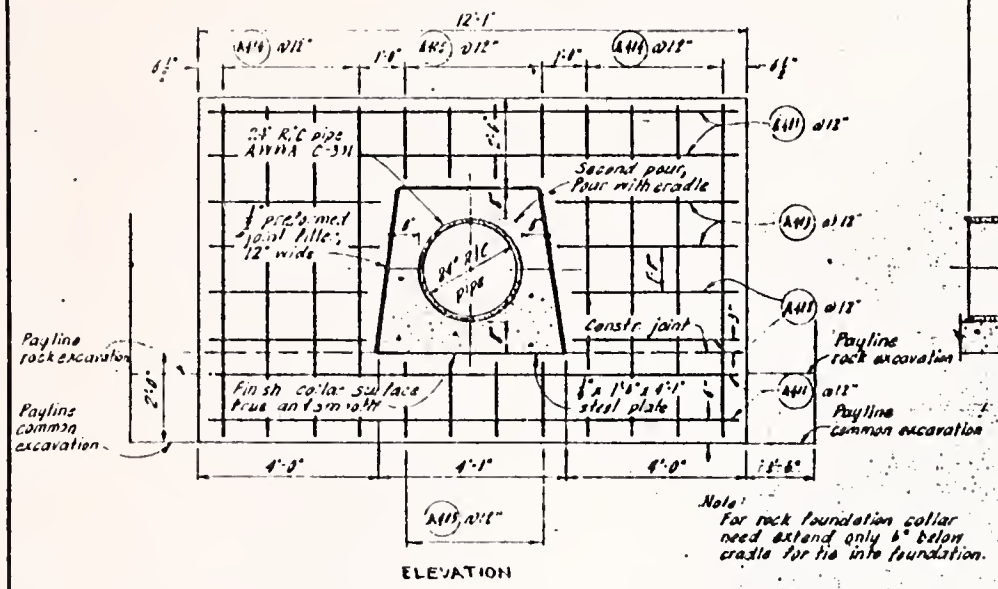
Title

Scale

Sheet No. 21 of 26 sheets

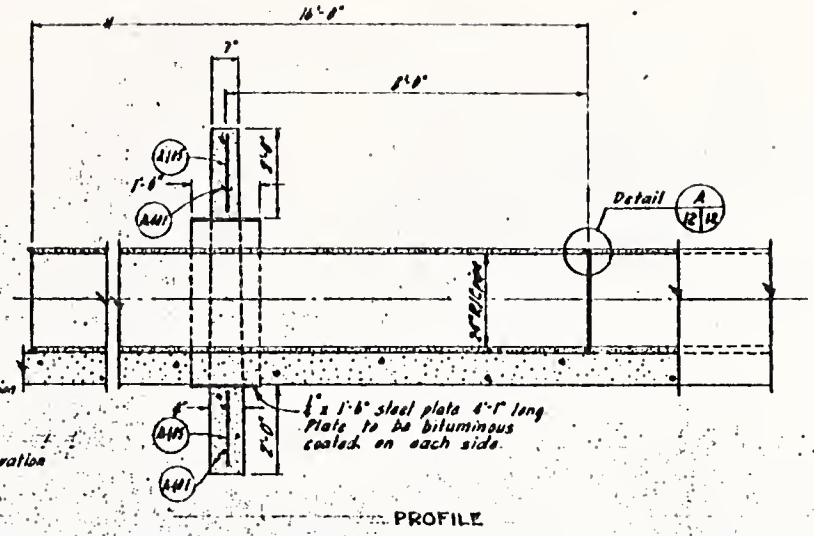
Drawing No. 7-E-20547

SCS-313C (9-64)



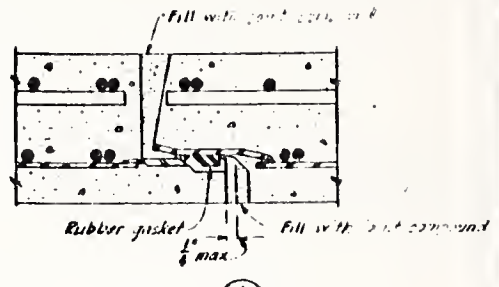
ELEVATION

Note: For rock foundation collar need extend only 6" below cradle for tie into foundation.



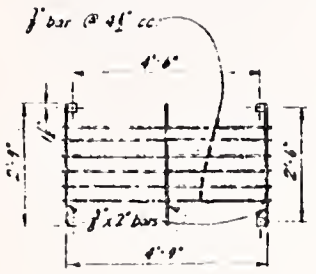
OUTLET CONDUIT AND ANTI-SEEP COLLAR

SCALE IN FEET

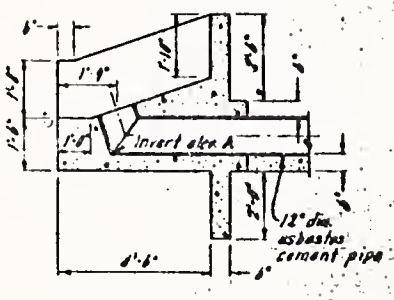


DETAIL A 12 12

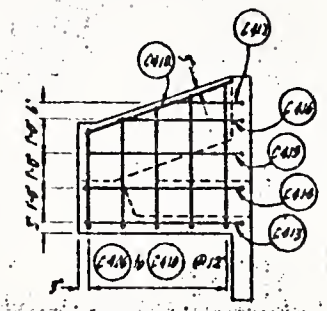
NOT TO SCALE



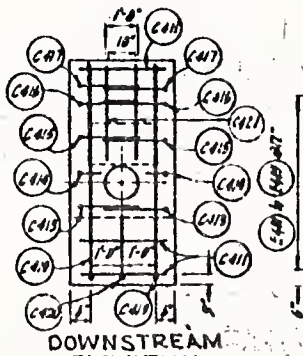
PLAN



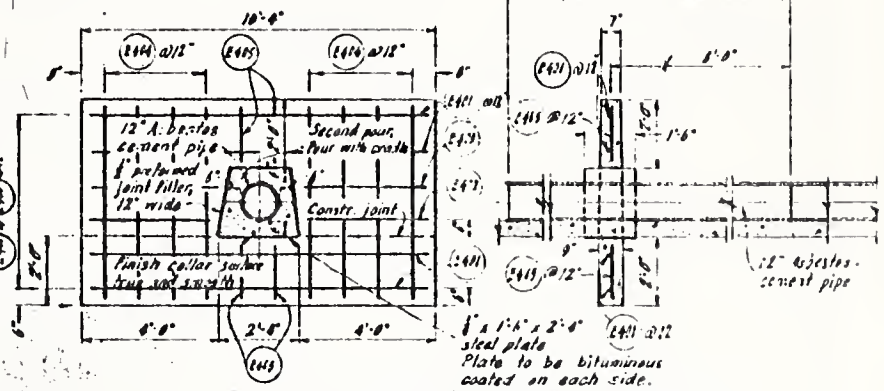
SECTIONAL ELEVATION



SIDEWALL ELEVATION



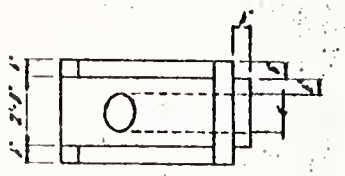
DOWNSTREAM ELEVATION


12" Asbestos cement pipe
2" preformed joint filler, 12" wide
Second pour, Pour with cradle
Constr. joint
Finish collar surface true and smooth
1/2" x 1'-6" x 2'-0" steel plate
Plate to be bituminous coated on each side.
12" asbestos-cement pipe

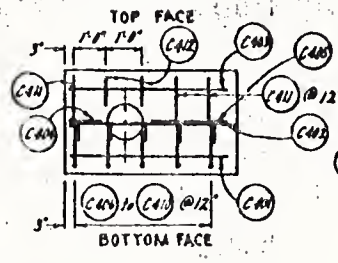
DRAIN CONDUIT AND ANTI-SEEP COLLAR AND NON-REINFORCED CRADLE

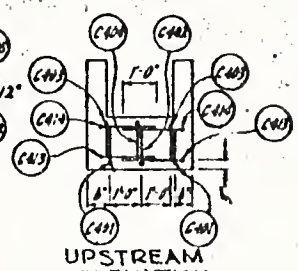
DETAILS

TRASH RACK



PLAN





UPSTREAM ELEVATION

DRAIN INTAKE

DRAIN INTAKE, DRAIN CONDUIT AND ANTI-SEEP COLLAR DETAILS

SCALE 1 0 10 IN FEET

DRAIN INTAKE	
LOCATION	ELEV. A
DAM #1	4236.0
DAM #2	4210.0

PLATE 23

DRAIN INTAKE, DRAIN CONDUIT & ANTI-SEEP COLLAR DETAILS

FLOOD RETARDING DAM NO 1 & NO. 2

JAWBONE CREEK WPR

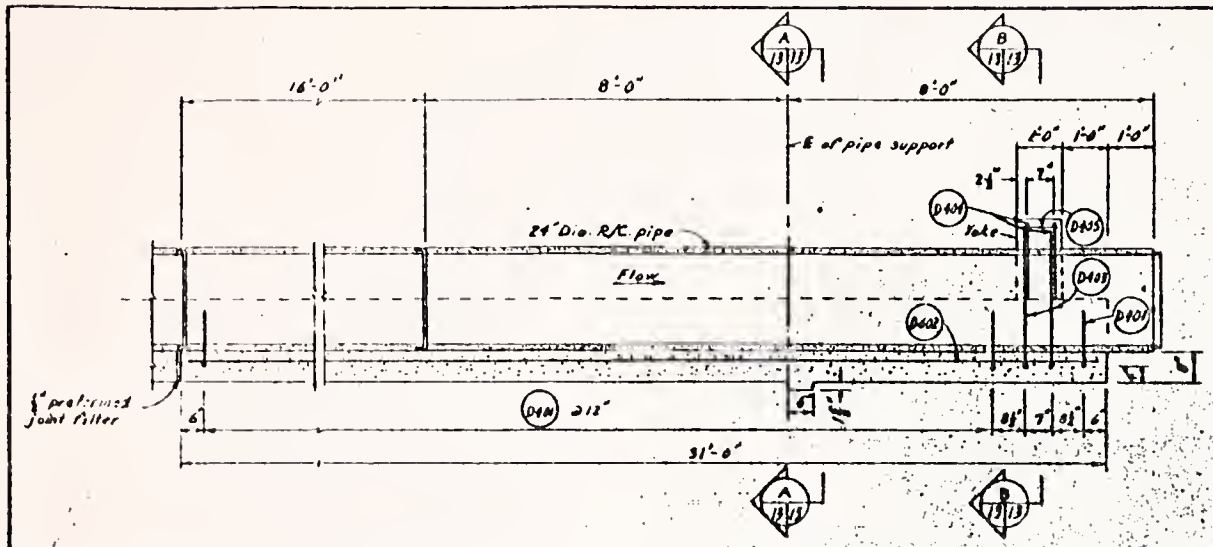
WHEATLAND COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

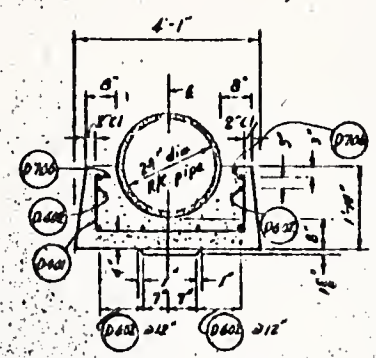
Designed	B B G, R S, M E H	Date 4-65	Approved by
Drawn	R V T.	4-65	Title
Traced			Title
Checked	M W. R M M E R 8 5-65		Sheet No. 12 of 15 — Drawing No. 7-E-20527

SCS-313C (9-64)

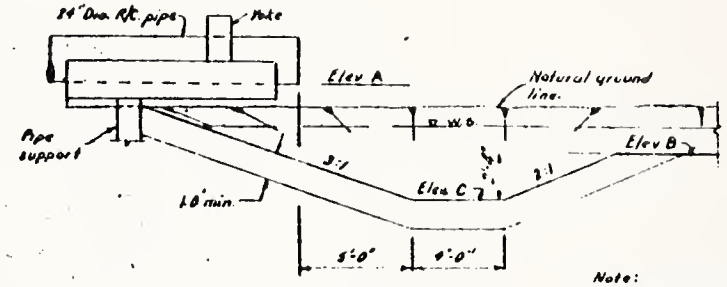
LOCATION	ELEV A	ELEV B	ELEV C
DAM NO 1	4233.0	4234.3	4228.0
DAM NO 2	4203.0	4200.3	4198.0



ELEVATION ON ℄ OF PRINCIPAL SPILLWAY

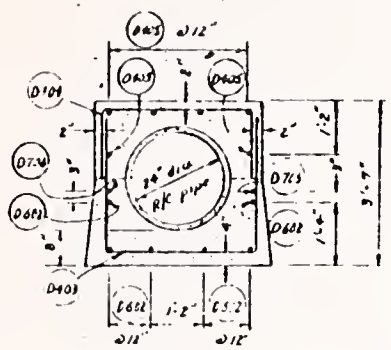


SECTION A 13/13

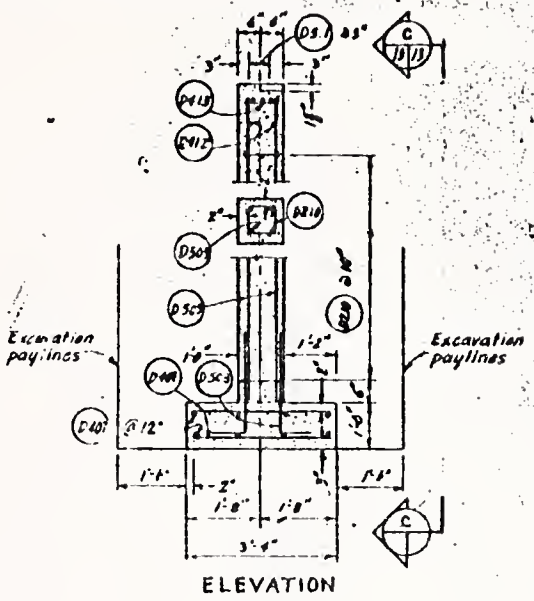


ELEVATION

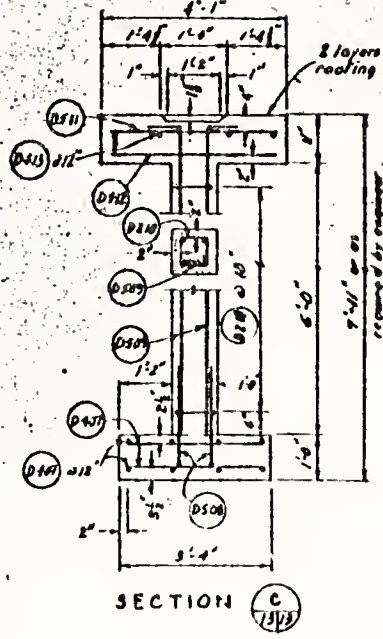
Note:
Rock riprap to be added as determined by field engineer.



SECTION B 13/13



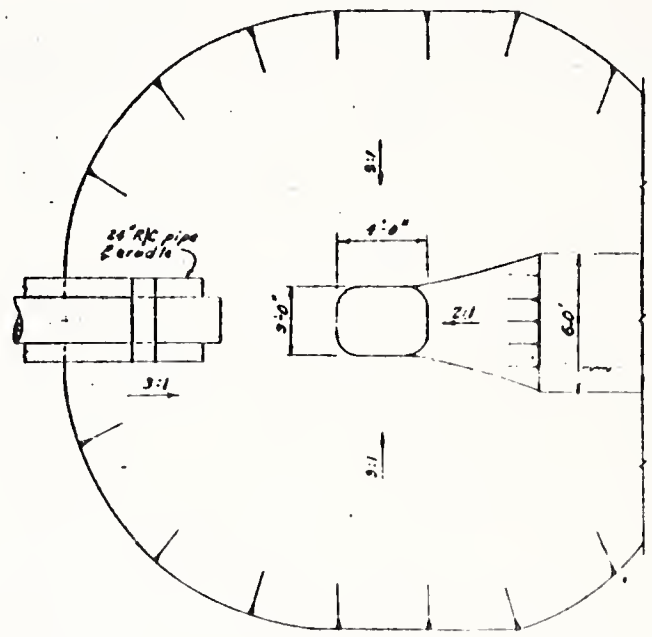
ELEVATION



SECTION C 13/13

CANTILEVER OUTLET DETAIL

Scale in Feet



PLAN

PLUNGE POOL DETAIL

Scale in Feet

PLATE 24

CANTILEVER OUTLET DETAILS
FLOOD RETARDING DAMS NO.1 & NO.2
JAWBONE CREEK WPP
WHEATLAND COUNTY MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed M E H	Date 5-65	Approved by	
Drawn J R N	5-65	Title	
Traced		File	
Checked M H & R.J.H. MEMBERS	5-65	Sheet No. 13 of 15	Drawing No. T-E-20527

SCS-313C (9-64)

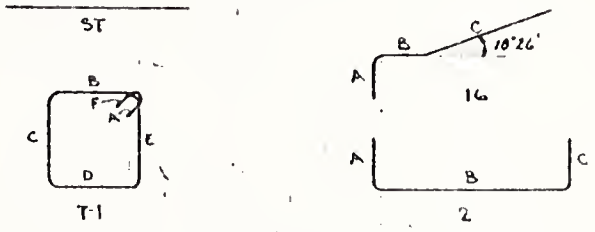
LOCATION	SIZE	MARK	TYPE	LENGTH	QUAN.	A	B	C	D	E	F	TOTAL LENGTH
Intake Structure												
	4	C401	2	5'-6"	2	1'-0"	4'-6"					11'-0"
	4	402	2	6'-0"	1	1'-0"	3'-0"					4'-0"
	4	403	16	3'-9"	2	1'-0"	0'-9"	4'-0"				11'-6"
	4	404	2	1'-9"	1	1'-0"	0'-9"					1'-9"
	4	405	St	3'-6"	1							3'-6"
	4	406	2	4'-9"	2	2'-0"	2'-9"					9'-6"
	4	407	2	5'-0"	2	2'-0"	2'-0"					10'-0"
	4	408	2	5'-3"	2	2'-0"	2'-3"					10'-6"
	4	409	2	5'-9"	2	2'-0"	3'-9"					11'-6"
	4	410	2	6'-0"	2	2'-0"	4'-0"					12'-0"
	4	411	St	2'-6"	4							15'-0"
	4	412	St	0'-9"	4							3'-0"
	4	413	2	8'-6"	2	2'-0"	4'-6"	2'-0"				17'-0"
	4	414	2	7'-0"	2	2'-0"	4'-6"	0'-6"				14'-0"
	4	415	2	6'-6"	2	2'-0"	4'-6"					13'-0"
	4	416	2	5'-3"	2	2'-0"	3'-3"					10'-6"
	4	417	2	4'-0"	2	2'-0"	2'-0"					8'-0"
	4	418	St	4'-6"	2							9'-0"
	4	419	St	4'-0"	2							11'-0"
	4	420	St	2'-0"	1							2'-0"
	4	D421	St	2'-9"	2							5'-6"
Cutoff Collar for 12" dia. pipe	4	B401	St	9'-9"	4							39'-0"
	4	402	St	3'-6"	2							7'-0"
	4	403	St	3'-9"	2							7'-6"
	4	404	St	5'-6"	4							44'-0"
	4	B403	St	1'-6"	4							6'-0"
Cutoff Collar for 24" pipe	4	A401	St	11'-6"	4							46'-0"
	4	402	St	3'-6"	4							14'-0"
	4	403	St	3'-9"	4							15'-0"
	4	404	St	7'-0"	4							56'-0"
	4	A403	St	1'-6"	8							12'-0"
Cantilever Outlet	4	D401	2	4'-0"	30	1'-3"	3'-6"	1'-3"				180'-0"
	4	402	St	30'-6"	6							183'-0"
	4	403	2	9'-6"	2	3'-0"	3'-6"	3'-0"				19'-0"
	4	404	2	6'-6"	2	1'-6"	2'-6"	1'-6"				13'-0"
	4	405	St	0'-9"	4							4'-0"
	7	706	St	30'-6"	2							61'-0"
	4	407	St	3'-0"	16							48'-0"
	3	306	2	3'-3"	4	1'-0"	2'-3"					13'-0"
	3	308	2	7'-6"	4	1'-0"	4'-6"					20'-0"
	2	210	Y1	2'-0"	7	0'-3"	0'-6"	0'-6"	0'-6"	0'-6"	0'-3"	81'-0"
	3	311	St	3'-9"	3							11'-3"
	4	412	St	3'-9"	2							7'-6"
	4	D411	St	0'-9"	4							3'-0"
River	4	B401	St	10'-6"	12							126'-0"
	4	402	St	6'-6"	9							58'-6"
	4	403	St	6'-6"	9							58'-6"
	4	404	St	3'-6"	8							28'-0"
	4	405	St	6'-9"	2							13'-6"
	4	406	St	5'-9"	2							11'-6"
	4	407	2	10'-0"	16	1'-0"	9'-0"					160'-0"
	4	408	2	10'-3"	4	3'-6"	4'-9"					41'-0"
	4	409	2	9'-3"	4	3'-6"	5'-9"					37'-0"
	4	R410	2	9'-9"	12	3'-0"	6'-9"					117'-0"

LOCATION	SIZE	MARK	TYPE	LENGTH	QUAN.	A	B	C	D	E	F	TOTAL LENGTH
Riser	4	B411	St	6'-9"	14							108'-0"
	4	412	2	10'-3"	18	3'-0"	4'-3"	3'-0"				184'-6"
	4	413	2t	6'-3"	37							242'-3"
	4	414	St	6'-3"	10							62'-6"
	4	415	St	10'-6"	4							42'-0"
	4	416	St	7'-3"	5							38'-6"
	4	417	St	3'-6"	4							14'-0"
	4	418	2	3'-3"	4	1'-3"	0'-9"	1'-3"				12'-0"
	4	419	2	11'-3"	4	3'-4"	4'-3"	3'-6"				43'-0"
	4	420	St	3'-6"	8							24'-0"
	4	421	St	4'-0"	8							32'-0"
	4	422	2	9'-3"	4	2'-6"	4'-3"	3'-6"				37'-6"
	4	B423	St	5'-6"	8							20'-0"

The steel in this schedule shows the requirements for only one (1) of the structural items indicated.

Number required are as follows:

Intake structure	- 1
Cutoff collars (12" dia. pipe)	- 2
" " (24" " ")	- 10
Cantilever outlet	- 1
River	- 1



BAR TYPES

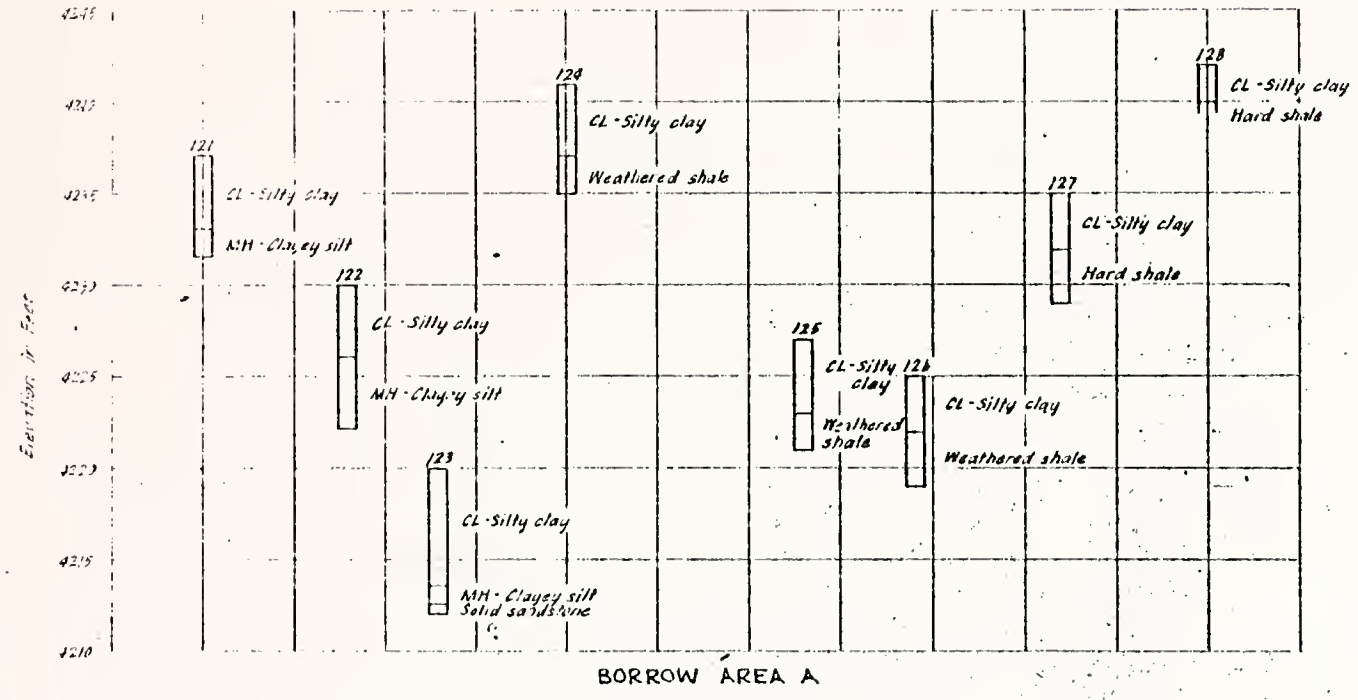
PLATE 25

STEEL SCHEDULE
FLOOD RETARDING DAM NO. 2
JAWBONE CREEK W.P.R.
WHEATLAND COUNTY, MONTANA

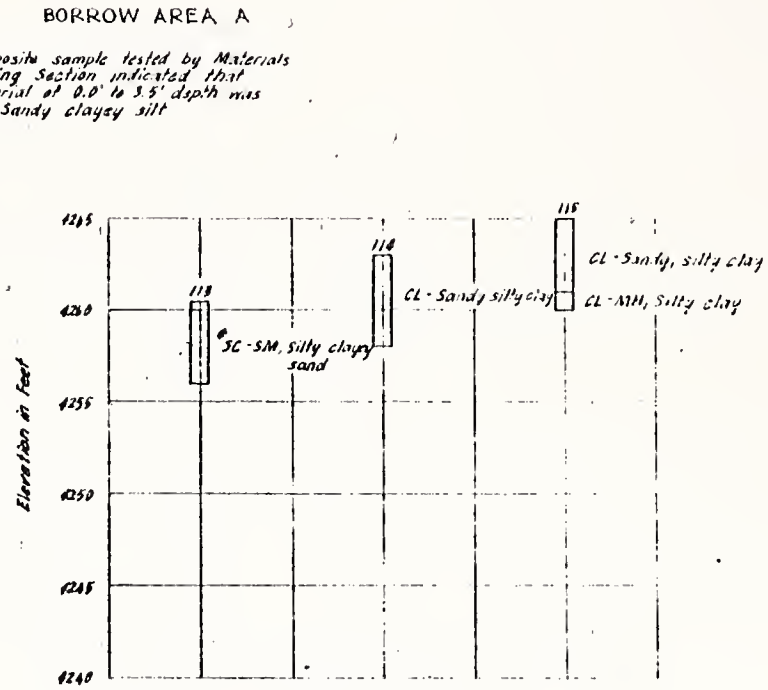
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed M.E.N. 2-56 Date
Drawn
Traced
Checked M.E.N. - H.M.R. 2-56
Approved by
Title
Title
Sheet No. 11 of 27
Drawing No. [illegible] 70971

7 E 20461

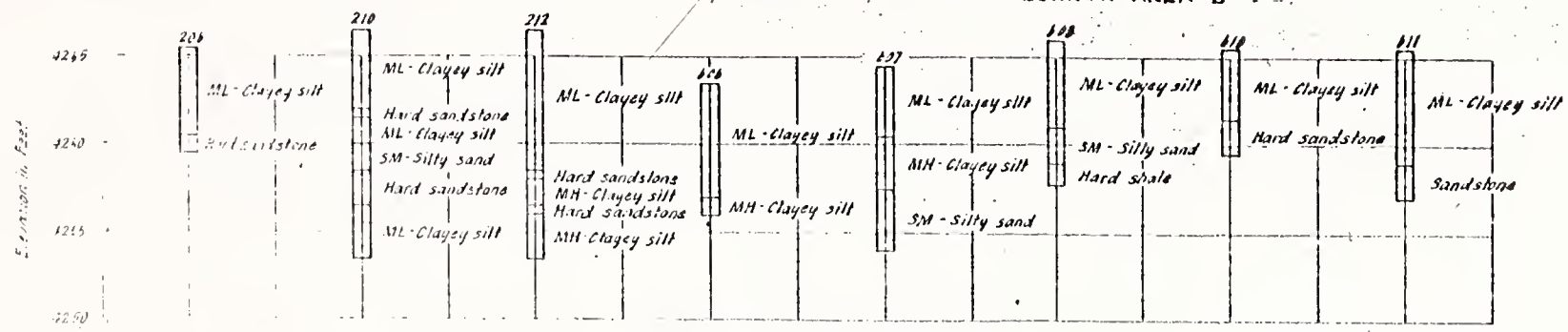


BORROW AREA A



BORROW AREA B

BORROW AREA B



EMERGENCY SPILLWAY

PLATE 26

LOG OF TEST HOLES
FLOOD RETARDING DAM NO. 1 & NO. 2
JAVIDINE CREEK WEB
WHEATLAND COUNTY, MONTANA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed B.B.G., R.C., M.E.H.	Date 4-65	Approved by	
Drawn K.V.T.	4-65	Title	
Traced		Title Sheet No. 15 of 15	Drawing No. [illegible]
Checked K.W. [illegible]	5-65		

SCS-313C (9-64)

APPENDIX A

OPERATION AND MAINTENANCE AGREEMENT

Project Jawbone Creek
State Montana

OPERATION AND MAINTENANCE AGREEMENT

THIS AGREEMENT, made and entered into the 21 day of April, 1966, by and between the Soil Conservation Service, United States Department of Agriculture, hereinafter referred to as the "Service" and the City of Harlowton, hereinafter referred to as the "City" relates to the operation and maintenance of the following described Works of Improvement:

> Two single purpose floodwater retarding structures located in the NW¼ of Section 22, T8N, R15E, near the City of Harlowton, Wheatland County, Montana.

The estimated annual cost of operating and maintaining the works of improvement herein described is $444.00 based on present construction costs.

I. OPERATION

The parties hereto agree as follows to the operation of the works of improvement:

A. The Service will provide such technical services as are available for assistance in the proper operation of the works of improvement.

B. The City will:

1. Be responsible for the operation of the works of improvement simultaneously with the acceptance of the works of improvement from the contractor.

2. Prohibit the installation of gates or other obstructions of any kind being placed in any portion of the principal or emergency spillways.

3. Prohibit any works to raise any portion of the spillways above the planned elevation or to deflect or decrease the planned flow through the spillways in any manner.

4. Prohibit the installation of dikes or other structures which may decrease the capacity of the flood channel or deflect the flow from the constructed channel bottom.

5. Take all other necessary steps to insure that the works of improvement are permitted to function in the manner for which they were designed, and are operated in accordance with any applicable State Law.

6. Gate on principal spillway of Dam No. 1 and Dam No. 2 will be closed to the pre-set opening at all times. Gates may be opened to unplug or remove debris if necessary, but shall be closed again to the pre-set opening immediately after unplugging.

II. MAINTENANCE

The parties hereto agree as follows to the maintenance of the works of improvement:

A. The Service will:

1. Inspect the works of improvement at least annually.

2. Prepare and furnish to the City a report of inspection findings including recommendations for maintenance work needed and when such work should be completed.

3. Provide such technical services as are needed and available for preparing plans, designs and specifications for needed maintenance of the works of improvement.

B. The City will:

1. Be responsible for maintenance of the works of improvement simultaneously with acceptance of the works of improvement from the contractor.

2. Inspect the works of improvement at least annually and after every major storm or the occurrence of any other unusual condition that might adversely affect the works of improvement to insure proper functioning and to check for possible damage or deterioration. Items to be checked at time of inspection may include, but not be limited to, the following:

a. Principal spillways.

(1) Damage or obstructions.
(2) Condition of outlet and riser.
(a) Signs of seepage.
(b) Separation of joints.
(c) Cracks or breaks.
(d) Differential settlement.
(3) Sediment level in relation to top of riser.

b. Emergency spillways - drainage ways.
(1) Erosion.
(2) Sedimentation.
(3) Weeds, logs and other obstructions or accumulations reducing channel capacity.
(4) Conformity with original design (deposition or sloughing).

c. Reservoir area.
   (1) Undesirable vegetative growth.
   (2) Cut or fallen trees.
   (3) Slash and other debris.
d. Embankments.
   (1) Settlement or cracking.
   (2) Erosion.
   (3) Leakage.
   (4) Rodent, wildlife or livestock damage.
   (5) Condition of vegetative cover.
e. Flood channel.
   (1) Sedimentation.
   (2) Bank cutting.
   (3) Debris accumulation.
   (4) Condition of riprap and other works.
      (a) Undermining.
      (b) Damage or deterioration.
      (c) Adjacent channel scouring.
   (5) Adjacent property damage.
f. Fences and Gates.
   (1) General condition - Repairs needed.
      (a) Loose or damaged posts.
      (b) Loose or broken wires.
      (c) Accumulated debris.
      (c) Open gates.

3. Perform, in accordance with any applicable State laws, all maintenance needs indicated by inspections and reports thereof within the time limits specified, if any, in such manner as not to damage the works of improvement in any way. Maintenance may include, but not be limited to, the following:

   a. Remove and burn debris.
   b. Refill, smooth and vegetate rilling on embankments, spillways, and drainage ways.
   c. Realign disposal channel where needed.
   d. Repair damaged riprap or other works.
   e. Repair fences and gates where needed.
   f. Other maintenance work as indicated in Service inspection reports.

4. Prepare a report for each inspection performed and furnish one copy to the Service. Maintain a record of all maintenance work performed and make such records available for review by the Service.

5. Perform operation and maintenance by the use of contributed labor and equipment, by hired labor and equipment, by contract or by a combination of these methods.

6. Obtain operation and maintenance funds by a tax levy.

III. IT IS MUTUALLY AGREED THAT:

A. Government Representatives shall have the right of free access to inspect the works of improvement at any time.

B. Whenever possible the parties to this agreement will make their annual inspections jointly. It is desirable that the annual inspections be made during the month(s) of May and June. Any supplemental inspections then determined necessary will be scheduled and agreed to at that time.

C. The City will secure prior Service approval of any agreement(s) to be entered into with other parties for any operation or maintenance of these works of improvement and furnish the Service with 3 copies of such agreements. If the agreement does not state a specific effective date, the City will notify the other parties to the agreement in writing of such date. Three copies of the notification will be provided the Service.

No Member of Congress or Resident Commissioner shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

This action authorized at an official meeting of City Council, Harlowton, Montana on 21 day of April, 1966, at Harlowton State of Montana.

Attest: /S/ S. D. Piper
(Name)

Clerk
(Title)

City of Harlowton, Montana

By: /S/ W. E. Munce, Mayor
(Title)

Date: 4-21 1966.

Soil Conservation Service
United States Department of Agriculture

By G A Brant
State Conservationist
STATE ADMINISTRATIVE OFFICER

Date: April 24 1966

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

January 22, 1981

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on the Jaw Bone Reservoir Dams No. 1 (MT-70) and No. 2 (MT-71). We concur with the findings and recommendations in the report and feel that the report satisfies the criteria for the Phase I investigation. Our comments have been discussed with your staff and we understand that they will be incorporated into the final report.

Thank you for the opportunity to review and comment on the final report for this project.

Sincerely,

Richard L Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB:LT:lj

"AN EQUAL OPPORTUNITY EMPLOYER"

United States Department of Agriculture
Soil Conservation Service
P.O. Box 970
Bozeman, MT
59715

December 10, 1980

Sidney Knutson, P.E.
Assistant Chief
Engineering Division
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

Thank you for the opportunity to review the final draft report on the Jawbone Dams and Dike (MT 70, MT 71, and MT 785).

Our comments relating to specific report statements are:

Page 9: A detailed geologic report and soil parameters based on lab test results, a slope stability analysis for both dams, and construction control records were and are available in the Bozeman SCS state office.

Page 19, line 1: Should "volume" be "peak flow" or should "cfs" be "ac-ft"?

Page 19, line 12: Would the ground be frozen at the same time irrigation water is flowing?

Page 29, line 16: Remove "of the SCS". The District is independent of the Soil Conservation Service.

We do not agree with the hydrologic conditions used to develop the probable maximum flood. The conditions selected attempt to eliminate the element of risk to a degree that we feel is not practical or reasonable. Despite the climatic differences, the Omaha District appears to be imposing much more reasonable hydrologic conditions than is the Seattle District. We suggest that a common degree of risk (probability) be applied by the COE nationwide.

Sincerely,

Van K Haderlie

Van K Haderlie
State Conservationist

cc:
Ray Smith, Acting State Conservation Engineer, SCS, Bozeman
Dave Jones, Environmental Engineer, SCS, Bozeman